UNITED STATES
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A NAVAL STORES HANDBOOK

DEALING WITH THE PRODUCTION OF PINE GUM OR OLEORESIN

▼

COMPILED BY

THE FOREST SERVICE
THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
AND THE BUREAU OF PLANT INDUSTRY

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INTRODUCTION[1]

The United States for more than a century has been the world's largest producer of turpentine and rosin (*214*)[2] (fig. 1). This naval stores[3] industry represents an annual output of approximately $50,000,000 worth of products obtained from more than 100,000,000

[1] By Eloise Gerry, Forest Products Laboratory, Forest Service. Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Italic numbers in parentheses refer to Literature Cited, p. 166.

[3] Naval stores is a term used for pine tree chemicals, specifically turpentine and rosin, the products of the oleoresin obtained from the living tree, or from the wood, of certain species of pines (*525*). In the past it included tar and pitch, and such derivatives used in wooden ships.

longleaf and slash pine trees. The industry is of basic importance to the Nation, as its products are made use of in the manufacture of paint, varnish, linoleum, paper, soap, ink, grease, synthetic camphor, and many other articles (*305, pp. 137–144; 314; 353; 436; 471; 535*). It is of vital importance to the Southeastern States because it employs more than 50,000 people. The average annual value of its products gives it a foremost place among southern industries. Naval stores production, moreover, can be undertaken not only by the large operator or timber owner but also by the farmer having some acres better suited for growing forest trees than for other crops (*379, 453*). It is a key industry in the South, since it yields

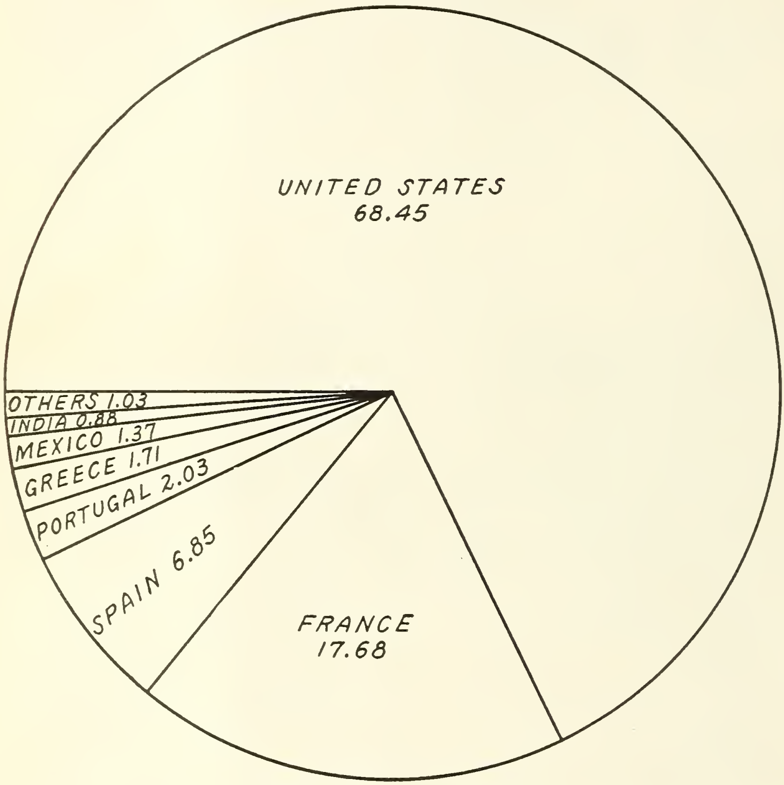

FIGURE 1.—Approximate percentage of world's production of turpentine, 1930–31, by countries (*214*).

early returns from land that, under present conditions, can be used most advantageously for the growing of pine trees (*70, 551*).

In addition to the pine products obtained from the oleoresin of living trees (gum naval stores) which are the chief subject of this publication, naval stores are also obtained from the wood remaining in the forest after the felling of the virgin pine stands (wood naval stores) (*525*). By utilizing stumps, roots, and other wood residues, which have a high resin content (lightwood), turpentine and rosin as well as pine oil and other products (*274, 277, 352, 495*) are obtained by two principal methods. These are known as (1) destruc-

tive distillation, the older method (*197*) and (2) extraction or steam and solvent distillation (*352*, *413*, *414*), which has increased rapidly during the last two decades.

As byproducts of the sulphate pulping process products known as sulphate turpentine and liquid rosin are also obtained in limited amounts (*317*).

In the United States about 10 percent as much turpentine and 20 percent as much rosin have been obtained in recent years from wood residues as were obtained from the gum exuded from living trees. The modern character of the steam-distillation plants and the up-to-date chemical methods employed, which are based on knowledge obtained through scientific research (*63*, *413*, *414*) into the characteristics and properties of the compounds handled, stand as significant examples of the application of the most recent advances in industrial development. Gum naval stores, by contrast, have long been marketed in a relatively crude form as a consequence of the rather primitive methods often employed in the course of small-scale production in remote places. The time, however, is now ripe for a further general improvement, refinement, diversification, and standardization of all pine tree chemical products (*551*).

PURPOSE

This handbook aims to give in encyclopedic form, for ready reference, an illustrated summary to date of information on where and how pine gum, or oleoresin, is obtained from living trees with suggestions for improving methods of production. The information presented here, if applied, should result in more profitable returns from the forests, reduction of forest wastes, and improved products from the second-growth longleaf and slash pines in the Southeastern States.

Information on the conversion of the gum or oleoresin into other products and their uses is not within the scope of this publication but may be obtained from the Bureau of Chemistry and Soils, United States Department of Agriculture, Washington, D.C.

PINES IN THE UNITED STATES THAT YIELD NAVAL STORES IN COMMERCIAL QUANTITIES

Among the 37 species (*513*) of pine native to the United States, only longleaf and slash are at the present time of major importance in the commercial production of so-called "naval stores", turpentine and rosin. These two species, together with associated species of southern pines, and certain western pines that present commercial possibilities for the production of gum are discussed in the following pages.

ENVIRONMENT OF THE SOUTHERN PINES [4]

The large area occupied in the Southern States by longleaf and slash pines is shown in figure 2. A considerable part of this area is better suited for the growing of forests than of other crops. If the loblolly and shortleaf pine areas are also included it is estimated that about 1 out of every 4 acres of forest land in the United States is southern pine land.

[4] Compiled by Eloise Gerry, Forest Products Laboratory.

The approximately 52,000,000 acres of potential longleaf and slash pine land lie chiefly within what is known as the coastal plain (*533, 579*) (fig. 3). The topography is gently rolling, except in the

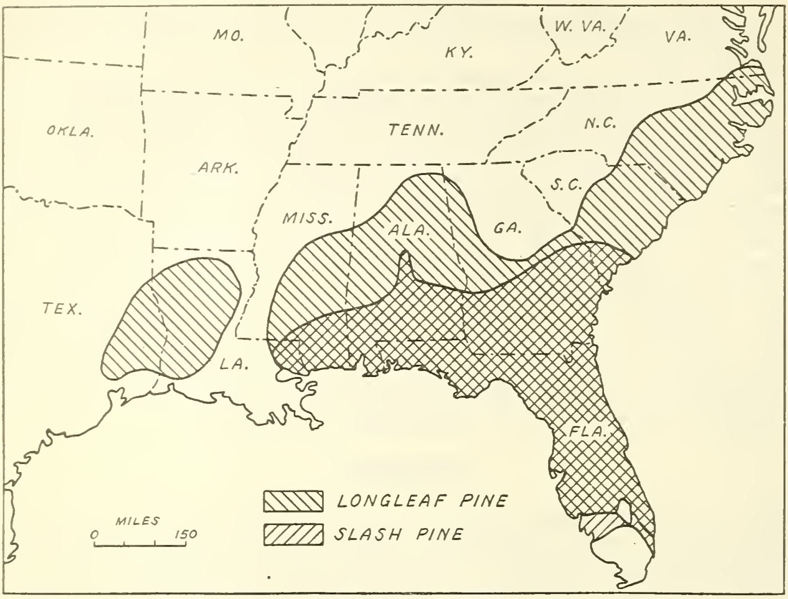

FIGURE 2.—Natural range of slash and longleaf pine in the United States.

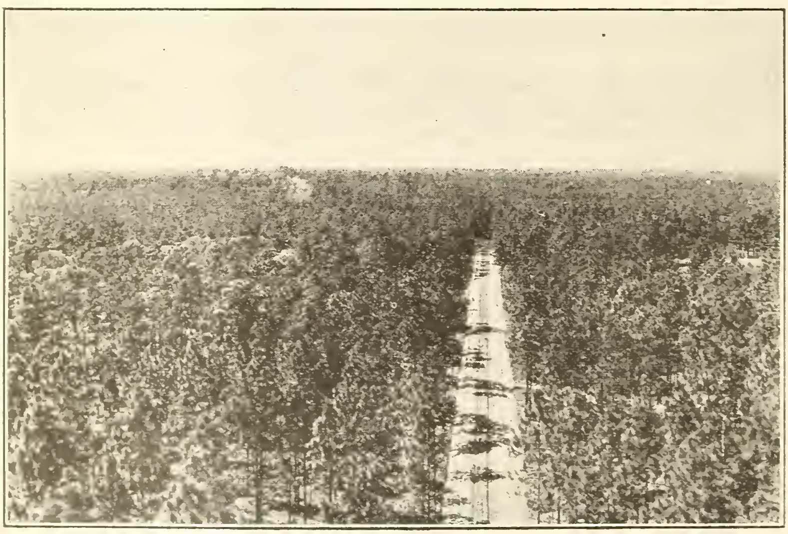

FIGURE 3.—Osceola National Forest, northern Florida, traversed by a Forest Service road.

portion known as the flatwoods. Swamps, or wet prairies, are frequent throughout the region, especially along the rivers, and near the coast.

The soils, derived from sediments deposited in shallow ocean water when the land was lower, are largely sandy or loamy and commonly of low fertility but capable of supporting pine-forest growth. They vary widely in timber-growing capacity (*201*). On sands underlaid by permeable clay the growth may be three times as fast as on the deepest sands (p. 82).

An undergrowth of bushes, herbs, and grasses, which vary widely with locality and site, is associated with the pines (*428*).

The greater part of the southern pine region was originally covered with forest; a relatively small percentage of the originally forested land has been cleared for agricultural use but there remains available for forest growth about two-thirds of the area, much of which under increasing fire protection is restocking with vigorous

FIGURE 4.—Throughout most of the pine woods the range is free and cattle graze at will.

young growth (*49*, *50*, *265*, *266*, *267*, *268*, *269*, *270*, *363*, *365*, *392*, *398*, *399*, *400*, *401*, *498*, *533*). The production of cattle is also one of the important industries of the region. They are grazed in the pine woods which are sufficiently open, as well as on the cut-over land (fig. 4). Gradually the desirable carpet grass (*Axonopus compressus* (Swartz) Beauv.), a species introduced from South America, is spreading and being propagated as an aid to grazing. Where this grass thrives, as on typical flatwoods land, it tends, if grazed, to reduce fire hazards in the woods.

The climate of the region where longleaf and slash pine grow is warm, equable, and moist. The mean summer temperature is about 80° to 82° F. and the mean winter temperature ranges from 51° along the northern border to 70° in southern Florida (table 1). Along the northern border of the region there is a frostless season of about 200 days; the first frost of the season occurs about October 25 and the last about April 10. Along the southern border the frostless season is about 90 days longer.

TABLE 1.—*Average temperature in the Turpentine Belt of the United States* [1]

Month	Wilmington, N.C.	Charleston, S.C.	Savannah, Ga.	Valdosta, Ga.	Jacksonville, Fla.	Tampa, Fla.	Pensacola, Fla.	Mobile, Ala.	New Orleans, La.	Lufkin, Tex.
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
January	46.0	49.0	51.8	52.0	55.0	60.3	52.8	49.8	54.2	51.8
February	48.0	52.0	53.2	53.5	57.7	61.7	55.0	53.2	56.8	53.8
March	54.0	57.0	59.6	61.4	62.9	67.0	60.8	59.1	63.7	61.4
April	60.0	64.0	65.8	67.2	68.4	70.7	66.8	66.0	68.7	66.7
May	69.0	72.0	73.6	75.5	75.1	76.5	73.7	73.6	75.2	73.7
June	76.0	78.0	79.1	80.6	80.2	80.1	79.5	79.1	80.7	81.2
July	79.0	81.0	81.5	81.8	82.4	81.3	80.6	80.5	82.3	83.8
August	78.0	80.0	80.8	81.3	81.7	81.5	80.9	79.7	83.9	83.8
September	73.0	76.0	76.4	78.3	78.4	79.9	78.2	76.5	79.0	78.7
October	63.0	67.0	67.7	68.2	70.3	74.3	69.8	67.1	70.7	67.8
November	54.0	58.0	58.8	59.0	62.3	66.9	60.3	57.5	61.7	59.1
December	47.0	51.0	52.0	52.1	55.9	61.1	54.0	51.5	55.3	51.6
Year	62.2	65.4	66.7	67.6	69.2	71.8	67.7	66.1	69.4	67.8

[1] Data from Naval Stores (*4*).

The rainfall is usually abundant at all seasons (table 2). The annual rainfall, except along the coast, ranges from 50 to 60 inches. It is greater in summer than in winter, especially along the western coast of Florida, where thunderstorms are more frequent than elsewhere in the United States. These conditions are admirably suited to pine-tree growth (*77*). The driest part of the year is generally in autumn but occasionally severe spring and summer droughts occur.

TABLE 2.—*Average rainfall in the Turpentine Belt of the United States* [1]

Month	Wilmington, N.C.	Charleston, S.C.	Savannah, Ga.	Valdosta, Ga.	Jacksonville, Fla.	Tampa, Fla.	Pensacola, Fla.	Mobile, Ala.	New Orleans, La.	Bon Weir, Tex.
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
January	3.50	3.35	2.83	3.57	3.01	2.62	3.96	4.85	4.47	5.46
February	3.39	3.38	3.32	4.04	3.31	2.74	4.49	5.36	4.20	4.26
March	3.59	3.67	3.39	3.43	3.35	2.25	4.90	7.17	4.44	5.24
April	2.86	3.44	2.90	3.01	2.80	1.72	3.90	4.35	4.72	5.90
May	4.03	3.44	3.06	3.57	4.34	2.71	3.17	4.00	4.25	5.57
June	5.62	5.24	5.71	6.37	5.35	7.73	4.55	5.95	5.39	3.62
July	6.97	7.35	6.26	5.95	6.22	7.80	6.70	7.04	6.58	4.19
August	6.51	6.83	7.57	5.92	6.19	8.40	7.89	6.81	5.77	7.96
September	5.27	5.28	5.25	4.11	8.01	6.89	5.55	5.02	4.65	2.97
October	3.74	3.74	3.27	2.21	4.97	2.59	4.01	3.18	3.50	4.51
November	2.45	2.75	2.24	1.75	2.32	1.88	3.70	3.74	3.73	4.13
December	3.12	3.05	2.91	4.07	3.04	2.07	4.67	4.57	4.63	4.59
Year	51.05	51.52	48.71	48.00	52.91	49.40	57.49	62.04	56.33	58.40

[1] Data from Naval Stores (*4*).

LONGLEAF PINE [5] (PINUS PALUSTRIS MILLER) [6]

Longleaf pine is also known as southern yellow pine, Georgia pine, hard pine, hill pine, heart pine, and longstraw pine.

[5] Compiled chiefly from the writings of W. R. Mattoon, extension forester, Forest Service, by Eloise Gerry, Forest Products Laboratory.
[6] Formerly designated *Pinus australis* Michaux.

GEOGRAPHIC DISTRIBUTION

Longleaf pine grows over a wide area (fig. 2) extending along the coastal region from southeastern Virginia to southern Florida and westward to eastern Texas; to northwestern Georgia, northward in Alabama to the northern part of the State, central Mississippi, and in western Louisiana (*40*, *194*, *271*, *475*, *513*).

HABITS AND GROWTH

Longleaf pine tends to grow in pure stands accommodating itself to a wide variety of sites, such as very poor, dry, deep sandy soils and moist, poorly-drained soils (crawfish land). It can also grow on soil with relatively impenetrable clay only 2 or 3 feet below the surface. This species withstands ordinary fires with relatively small injury (p. 122). It grows best in deep soils underlaid by clay. Its tendency to grow on sandy ridges has gained for it the frequently used name of hill pine.

During its early years, longleaf pine may grow much more slowly than shortleaf, loblolly, or slash pine. It grows faster on good soils than on poor soils, and may gain in height from 2 to 3 feet a year after height growth starts (table 3). Longleaf pine tends to have a good rate of growth for many years.

TABLE 3.—*Average height and diameter of longleaf pines at various ages, grown on different grades of soil, and average number of trees per acre in fully stocked stands* [1]

Age of trees	Height of average dominant trees on land classed as—			Diameter of trees 4½ feet above the ground in dominant stands on land classed as—			Trees 7 inches and over in diameter on an acre of land classed as—		
	Excellent [2]	Good [3]	Poor [4]	Excellent [2]	Good [3]	Poor [4]	Excellent [2]	Good [3]	Poor [4]
Years	*Feet*	*Feet*	*Feet*	*Inches*	*Inches*	*Inches*	*Number*	*Number*	*Number*
15	33	26	18	4.6	3.8	3.0	13	3	----------
20	46	36	26	6.1	5.1	3.9	110	35	----------
25	57	45	32	7.1	6.0	4.7	211	112	----------
30	66	52	37	8.0	6.8	5.4	255	170	35
35	74	57	41	8.9	7.6	5.9	266	208	61
40	80	62	45	9.6	8.2	6.4	265	235	100
45	85	66	47	10.3	8.8	6.9	261	249	136
50	90	70	50	11.0	9.3	7.3	255	255	160
55	94	74	53	11.5	9.8	7.7	242	253	175
60	98	77	55	12.0	10.2	8.0	230	245	185
65	102	79	57	12.5	10.6	8.4	222	240	192
70	[5] 105	82	58	12.9	11.0	8.7	215	235	195
75	108	84	60	13.3	11.3	8.9	209	227	199
80	110	86	61	13.7	11.7	9.2	195	220	200
85	112	88	63	14.1	12.0	9.5	190	214	200
90	114	89	63	14.4	12.3	9.7	185	210	200
95	115	90	64	14.7	12.6	9.9	178	201	196
100	116	90	65	15.0	12.8	10.2	170	200	190

[1] Based on data furnished by the Southern Forest Experiment Station, New Orleans, La.
[2] Site index, or the normal height of a tree growing on this land for 50 years, was 90 feet.
[3] Site index, or the normal height of a tree growing on this land for 50 years, was 70 feet.
[4] Site index, or the normal height of a tree growing on this land for 50 years, was 50 feet.
[5] Mature longleaf pine rarely exceeds 105 feet in height (*530*).

Marked reduction or increase in precipitation during the growing season causes corresponding variations in the width of the annual rings in the growing wood (p. 111). An increment boring made on

one side of a tree gives as reliable an indication of the tree's growth as an average of borings on four sides, and no marked relationship exists between points of the compass and ring formation (*354*).

DISTINGUISHING CHARACTERISTICS

LEAVES

The length of the leaves (needles or straw) ranges from 8 to 18 inches (*355*). The leaves are flexible and bright green and tend to cluster in brushlike tufts, or bunches, at the ends of rather naked branches. There are usually three needles in a bundle, or fascicle. Leaf fall is more or less continuous, but periods of heavy fall occur and have been observed specifically during June and October in northern Florida. The leaves are shed at the end of their second year. An essential oil of balsamic odor resembling turpentine is obtained by distilling the green leaves.

The internal structure of pine needles is so characteristic that different species of pines may be identified with the aid of a microscope from cross sections of the needles (*51*, *142*, *171*, *264*, *372*).

TERMINAL BUDS

The conspicuous large silvery white buds and the characteristic whitish "candles" that develop from them in the process of new leaf formation, offer an easy means of identifying longleaf pine, especially in winter and spring.

BARK

The bark is about one-half inch in thickness and tends to be thickest on young vigorous trees. It is orange-brown. In mature trees it is characterized by broad, smooth scales.

CONES

The large size, 6 to 10 inches long and 2 to 3 inches in diameter at the base, of the closed cones, or burrs, readily distinguishes longleaf pine from other southern pines. The elongated cones are set on a short stalk. The scales have very short prickles, delicate and incurved. The cones mature at the end of the second season and are pendent. Trees differ greatly in their power to produce cones; some are produced on trees as small as 20 feet in height but they are comparatively few and the seed is likely to be infertile. Trees under 10 inches in diameter at 4.5 feet above the ground seldom bear more than 25 to 50 cones even in years of abundant crops of seed (*542*). The seed, however, may be of excellent quality although seeds from isolated trees, young or old, which receive insufficient pollen are frequently poor.

SEEDS

The seeds of longleaf pine are larger than those of the other southern pines, hence readily devoured by a wide variety of animals.

On account of their weight the seeds are not carried by the wind so far as those from other species. There are, however, records of seeds having been blown considerable distances, even as far as one-fourth of a mile, but commonly the distance is from 150 to 400 feet

FIGURE 5.—Root of a mature longleaf pine growing in Norfolk fine sand. (Black and white 12-inch ruler at ground level.)

(*87*). Ordinarily the seeds germinate in 3 to 5 weeks after they fall from the cone, although the regular germination time in a nursery is about 10 to 20 days.

A heavy production of longleaf pine seed does not, as a rule, occur every year, but some seeds are usually produced each year

and these partial crops vary in abundance from place to place. A single cone may contain 50 good seeds (*545*). A bushel of cones yields about 1 pound of unwinnowed seed. Longleaf pine seed has been collected in Texas when logging was in progress for a cost of about 50 cents a pound. The market prices in 1932 ranged from 50 cents to $3 a pound, the average price being about $1 a pound for seed purchased in large quantities.

FIGURE 6.—Taproot of a longleaf pine 30 years old and 4 inches in diameter breast high, the downward growth of which was checked by hardpan soil formation at a depth of 1½ feet. The tree was wind-thrown because of its poor support. (Rule marked in black and white inch squares.)

SEEDLINGS

The sprouted seed may have 5 to 10 seed leaves, or cotyledons, usually 7 or 8 (*545*), and the seedling is therefore classed as a polycotyledon. Seedlings from seeds from the same cone may vary widely in cotyledon number. Longleaf pine seedlings usually tend to have a very slow height growth during the first 3 to 8 years but have marked resistance to fire after the first year. Their growth, however, may be seriously retarded even by light ground fires.

ROOTS

Longleaf pine has a very large taproot and frequently 8 to 12 stout lateral roots. The taproot is sometimes seen when trees are uprooted or the roots otherwise exposed (fig. 5). Just below the surface of the ground the taproot is often nearly as large in diameter as the trunk of the tree and may even be 20 to 30 feet in length (*117*). The large taproots of the longleaf pine make the tree relatively firm against winds and able to live in deep, dry soils. On soil types that have an impenetrable clay, or hardpan, within a foot or two of the surface, the taproot cannot fully develop (fig. 6), and such trees may be thrown down by any ordinary wind (*201*).

Longleaf pine makes chiefly root growth during its first 3 to 5 years; the stem makes little or no growth in height during this

period. The young longleaf pine roots have a spongy bark that is so eagerly sought as food by hogs that serious destruction of young stands frequently results (p. 132).

The extent of the root competition that exists among the pines themselves and among the other plants that grow on the floor of the forest is very great. A longleaf pine tree, 3 inches in diameter breast high and 20 feet in height, growing in deep sand in western Florida was found, when the soil was washed away under hydraulic pressure, to have roots which occupied an elliptical area of 150 square feet, the longest axis being 19 feet and the shortest 10 feet (*220*) (fig. 7). The lateral roots branched from the taproot immediately below the root collar and in general occupied a zone from 1 to 3 feet beneath the surface, extending somewhat more horizontally than is indicated in figure 7. The roots therefore had access to the moisture and nutrients of approximately 17 cubic yards of soil, not considering the taproot.

The taproot was 5½ feet long, stocky, and a firm anchor for the little tree. From this root a few small lateral roots penetrated the deeper soils not invaded by the major laterals. The dimensions of

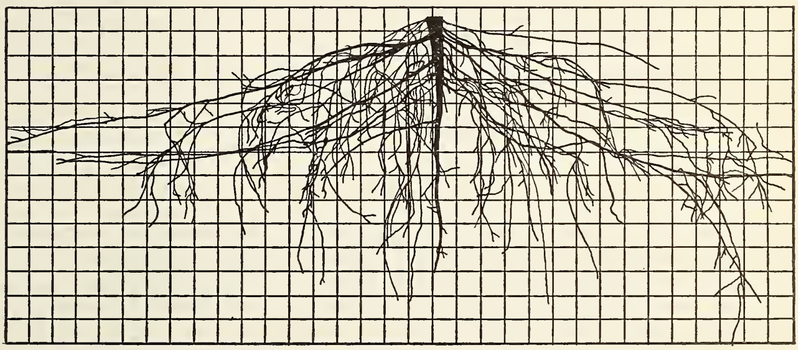

FIGURE 7.—Root system of a longleaf pine tree 3 inches in diameter breast high and 20 feet in height. Each square is 6 inches wide.

the roots of this small sapling suggest an idea of the extent and dimensions of the root system of a mature longleaf pine. Examination of several has shown that roots one-half inch in diameter are not infrequent at 30 feet from the tree, or twice the radius of the crown (*294*).

REPRODUCTION

Longleaf pine under normal conditions is capable of good reproduction from seed trees (*43*, *131*, *528*). It is, however, handicapped by abnormal conditions, such as frequent fires and by the fact that it does not seed freely each year (p. 118). Another cause of failure in reproduction is its tendency to shed all the seed in autumn from the cones at once, with the result that winter fires may destroy the whole crop.

Longleaf pine seed when stored by man rapidly deteriorates unless kept in tight containers and at low temperatures. Seed sealed in glass jars and held at a temperature of 25° to 30° F. showed about as

good germination after 2 years storage as fresh seed. After a year of storage in friction-top cans in an ice box at 32° to 35° a germination of 75 percent was obtained; similar seeds gave 89 percent germination when fresh (*546*). The best results are secured by man from autumn plantings.

The collection of seed may be accomplished with comparative ease. This is especially true when collections can be made during logging operations (p. 118).

OLEORESIN CONTENT

An investigation of the distribution of oleoresin in longleaf pine trees showed that in general the sapwood (p. 31) of the longleaf pine contains comparatively small proportions of resin, while the heartwood (p. 32) contains varying large proportions depending upon its location in the tree. The sapwood may contain about 2 percent of resin, the average heartwood 7 to 10 percent, heartwood in the butt log 15 percent, and the heartwood of the stump 25 percent (*211*, *285*, *402*, *522*). It is from the sapwood of the living tree, however, that the oleoresin of the gum-turpentine industry is obtained because it is there that it is manufactured by the living cells of the tree. The resin present in the heartwood does not exude when the tree is wounded. The heartwood resin is obtained only when the chipped wood is treated with solvents, such as gasoline, turpentine, or ether.

IMPORTANCE OF THE SPECIES

NAVAL STORES PRODUCTION

Longleaf pine has in the past yielded the bulk of the turpentine and rosin produced in the United States (*134*). The effect of turpentining by boxing (p. 54), as conducted in former years, on the strength of the timber was determined for specimens of virgin longleaf pine (*402*). The belief had been that turpentining reduced the strength of the timber. The results of the tests proved conclusively that extracting gum, even by the severe methods then in use, did not injure the strength qualities of the wood, and that unless the butt log was seen the lumber from turpentined and unturpentined timber could not positively be differentiated. Since no gum was extracted from the heartwood its decay resistance, or durability, was not affected.

Several workings for turpentine will, however, degrade the butt lumber in the region of the faces on young trees if turpentining is begun when the trees are as small as 10 inches in diameter at 4½ feet above the ground. For this reason low chipping, which will reduce the butt scar while giving high yields, is of importance (p. 62).

LUMBER PRODUCTION

Since 1899, southern pines, including longleaf, slash, loblolly, and shortleaf, have furnished 30 to 40 percent of the lumber for the United States. Longleaf pine makes up a large proportion of the total annual cut of southern yellow pine.

For characteristics of the wood see table 4.

TABLE 4.—*Characteristics of the four most commercially important southern pines*

Characteristic or property	Longleaf	Slash	Loblolly	Shortleaf
Leaves:				
In bundle, or fascicle ... number	3 (rarely 4)[1]	2 or 3	3	2 or 3.
Length ... inches	8 to 18	6 to 12	3 to 10	1.5 to 6.
Color	Bright green	Dark green; glossy	Pale bluish green	Green (slightly bronzed).
Grouping	Bunched at ends of branches	Densely along branches	Densely along branches	Densely along branches.
Terminal buds and candles:				
Color	Silvery white, conspicuous	Cinnamon brown, almost purplish	Brownish	Brownish purple.
Diameter	About as large as a man's finger	Intermediate between longleaf and loblolly.	About as large as a lead pencil	Smaller than loblolly.
Position	Upright	Upright	Upright, droop at tips	Upright.
Cones:				
Length ... inches	6 to 10 (usually 6 to 8)	2.4 to 6.5 (usually 3 to 5)	2.5 to 6	1 to 3.
Maximum diameter open ... inches	4 to 6	2 to 5	2 to 3	1 to 2.
Maximum diameter closed ... inches	2 to 3	1 to 2 (usually 1.6)		
Shape (closed)	Elongated cylinder	Egg shaped	Broadly conical	Conical.
Stalk	Short	Short	No stalk	
Scales:				
Breadth at tip ... inches	0.5 to 1.0	0.7 to 0.8	0.5 to 0.75	0.3 to 0.5.
Prickle	Short, incurved	Short, straight	Long	Very short, straight, often deciduous.
Color	Dull light brown	Rich chocolate brown; shiny	Dull brown	Light brown.
Habit	Mostly shed second autumn	10 to 15 percent not shed second autumn; remain till following spring.	Many remain attached to tree several years.	Many persistent several years.
Seeds:				
Length without wing ... inch	About 0.5	About 0.25	Less than 0.25	Less than 0.25.
Color	Dark brown	Blackish		
Average number in pound (clean).	5,200	15,500	21,300	69,200.
Cost per pound (1932)	$0.50 to $3	$2.25		$2 to $8.
Natural germination ... days	10 to 14	17 to 21		
Seed leaves ... number	7 to 10	6 to 9		4 to 7.
Viability of stored seed[2]	2 years sealed, kept at 25° to 30° F			

[1] Specimens having 4 needles per fascicle collected by R. O. Marts in Osceola National Forest, Fla., 1931.
[2] Fresh seed is available annually, except for longleaf pine.

TABLE 4.—*Characteristics of the four most commercially important southern pines*—Continued

Characteristic or property	Longleaf	Slash	Loblolly	Shortleaf
Average weight and comparative strength properties of wood: [3]				
Trees tested ... number	34	10	10	12.
Specific gravity, oven dry, based on volume when green.	0.55	0.64	0.50	0.49.
Weight per cubic foot air dry (12 percent moisture) ... pounds	41	48	38	38.
Composite strength values:				
Bending strength	106	116	93	97.
Compressive strength (endwise).	123	126	104	104.
Stiffness	189	195	166	170.
Hardness	76	93	62	68.
Shock resistance	103	105	93	111.
Diameter of pith [4] ... inch	Large: Over 0.1	Highly variable	Under 0.1 except in very fast growing trees.	Under 0.1 except in very fast growing trees.

[3] Markwardt, L. J. (*370*). Individual pieces of any species show considerable variation from the average, and second-growth southern yellow pine may be somewhat lower in strength properties than the virgin-growth material for which the data are presented.
[4] Koehler, A. (*322, 323*).

PULP PRODUCTION

The southern pines have been the source of a steadily increasing proportion of the Nation's pulpwood (*154*). Longleaf pine wood has a relatively long fiber (p. 30) and when properly prepared is well adapted for paper pulp. An increasing number of pulp mills in the South utilize longleaf pine alone or mixed with other pines for pulp production. The chief product in 1931 was kraft pulp of high quality made by the sulphate process. For this use resin content is no drawback and both sapwood and heartwood are employed. Kraft pulp unbleached is used mainly for wrapping papers, paper boxes, bags for cement, container boards, and similar products. A few mills are producing other types of pulp including bleached material from this species. There is also a possibility judging from experimental work that the wood of longleaf pine, especially that from saplings, which contain little or no heartwood, may in future be manufactured into book papers and newsprint.

SLASH PINE [7] (PINUS CARIBAEA MORELET) [8]

Slash pine is also known as yellow slash, swamp pine, hill slash, and Cuban pine.

GEOGRAPHIC DISTRIBUTION

Slash pine grows in the coastal region (fig. 2) from South Carolina to southern Florida; westward in the coastal region of the Gulf States to Louisiana. It also occurs in Honduras, eastern Guatemala, Nicaragua, Bahamas, Cuba, and Isle of Pines (*513*).

HABITS AND GROWTH

Slash pine is one of the most rapidly growing forest trees in the United States. Growth in height is particularly rapid up to about 25 years of age. Slash pine is sensitive to fire during its early years; it is also easily damaged by poor turpentining practices, such as deep chipping (*386*). In the first year, seedlings commonly reach 8 to 12 inches in height. Slash pine may grow in pure stands or mixed with longleaf and other species. Extensive pure stands of virgin slash pine were rare except in the lower peninsula and Gulf coast of Florida. It grows naturally in the moister situations along swamps and ponds. It will tolerate a highly acid condition in the surface soil. It also grows on higher and drier sites and is then locally known as hill slash. Its present range is smaller than that of the other commercial southern pines. In the virgin forest it appears to have been relatively less abundant in proportion to longleaf pine than it is in the young growth and the planted stands today. In early days slash pine was confused with other species of southern pine. Slash pine grows rapidly (table 5) even in rather dense stands so that at 15 to 25 years it is often capable of giving excellent yields of naval stores. Slash pine was not prized in early days for naval stores because under the heavy

[7] Compiled chiefly from the writings and other information furnished by W. R. Mattoon, extension forester, Forest Service, by Eloise Gerry, Forest Products Laboratory.

[8] Formerly designated as *Pinus cubensis* Grisebach and as *P. heterophylla* (Elliott) Sudworth and as *P. elliottii* Engelmann (*513*).

chipping then used it tended to dry face (p. 63) and become unproductive more readily than longleaf pine. Moreover, it frequently grew in the less accessible places.

TABLE 5.—*Average height growth of slash pine, average diameter growth in open and close stands, and average number of trees per acre over 7 inches in diameter on soils of different quality at various ages* [1]

Age of trees	Height of average dominant trees on land classed as—			Diameter of trees 4½ feet above the ground						Trees 7 inches and over in diameter per acre in fully stocked stands on land classed as—		
				Open-grown stands on land classed as—			Close-grown dominant stands on land classed as—					
	Excellent [2]	Good [3]	Poor [4]	Excellent [2]	Good [3]	Poor [4]	Excellent [2]	Good [3]	Poor [4]	Excellent [2]	Good [3]	Poor [4]
Years	*Feet*	*Feet*	*Feet*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Number*	*Number*	*Number*
15	48	39	29	8.8	6.9	5.2	6.6	5.2	3.9	115	55	-------
20	61	48	36	10.3	8.0	5.9	7.7	6.0	4.4	255	150	40
25	71	56	42	12.3	9.6	7.1	9.2	7.2	5.3	330	265	110
30	79	63	48	13.7	10.8	7.9	10.5	8.3	6.1	300	305	175
35	86	69	52	15.2	12.0	9.0	11.7	9.2	6.9	240	305	245
40	92	73	55	16.6	13.1	9.9	12.8	10.1	7.6	210	295	275
45	96	77	58	17.1	13.5	10.1	13.7	10.8	8.1	185	280	295
50	100	80	60	18.1	14.2	10.7	14.5	11.4	8.6	170	260	305
55	103	83	62	18.8	14.8	11.0	15.0	11.8	9.0	160	245	315
60	106	85	64	19.4	15.2	11.6	15.5	12.2	9.3	150	230	320

[1] Based on data furnished by the Southern Forest Experiment Station.
[2] Site index, or the normal height of a tree growing on this land for 50 years, was 100 feet.
[3] Site index, or the normal height of a tree growing on this land for 50 years, was 80 feet.
[4] Site index, or the normal height of a tree growing on this land for 50 years, was 60 feet.

The slash pine trees growing under the conditions existing in the extreme southern portion of Florida are generally characterized by very dense wood formation, and are reputed to produce such poor yields of gum that profitable turpentining has been found impracticable in many cases. By some (*190*, *269*) these trees are considered to belong to a different species from the slash pine growing farther north.

DISTINGUISHING CHARACTERISTICS

LEAVES

The length of the leaves (needles or straw) of slash pine ranges from 6 to 12 inches, averaging about 9 inches long and one-sixteenth of an inch thick. The leaves are intermediate in size between those of longleaf and loblolly pine. They are a dark, glossy green; darker than either longleaf or loblolly pine. They are straight, flexible, and bear numerous minute sharp teeth along their margins. There are usually 2 but sometimes 3 leaves, especially in vigorous trees, in a bundle, or fascicle.

TERMINAL BUDS

The color of the winter buds containing the new leaves is a dark cinnamon brown, often purplish. In the early spring they open to form upright, brownish " candles ", which are about one-third of an inch in diameter.

BARK

The bark of the slash pine is irregularly divided into thin, dark red-brown scales. Young trees have a thick, deeply furrowed bark. The orange-colored or sometimes silvery bark plates of mature trees are characteristic of slash pine and make its identification easy.

CONES

The closed cones, or burrs, average 3 to 5 inches in length and about 1 to 2 inches in diameter. They are egg-shaped, narrowly oval to cylindroconical, and the color is a rich chocolate-brown. The thickened rounded ends of the thin cone scales are of a lustrous brown, and they are transversely marked by a sharp keel, or ridge, and armed with a short, fine, sharp, recurved prickle.

The cones mature at the end of the second season, are borne on short stems, and are pendent. After shedding seeds in September and October, some cones, at least in the eastern part of the range of the species, may remain on the trees till the following spring, when a secondary shedding of seeds may occur. The spring shedding has not been observed in Louisiana where complete shedding has been observed in autumn.

SEEDS

The size of the slash pine seed varies from about one-fifth to one-fourth of an inch in length. The wings are 4 or 5 times as long as the seeds and about one-fourth of an inch wide. The seed itself is blackish, plump, triangular, and delicately ridged on the under side. The seeds are readily carried by the wind.

Slash pine is the earliest to flower of the four important southern pines. The flowers open during late January or in February. This species is a good seed producer but large crops of seed occur only irregularly. The seed, like that of all pines, requires 2 years to mature in the cones. It is one of the first seeds to be discharged from the cones and to germinate in the autumn, but at the same time in the eastern part of the naval stores belt, about 10 or 15 percent of the cones have been observed to remain unopened throughout the winter and to discharge seed the following spring.

SEEDLINGS

Many seeds sprout soon after they fall, and by the end of October the young slash seedlings with their 5 to 9 cotyledons (usually 7 or 8), or seed leaves, may be found. By the close of the first summer the slash seedlings may be from 8 to 12 inches tall. Other seeds, however, do not germinate till the spring following their dissemination.

ROOTS

Slash pine is shallow-rooted as compared with longleaf pine. The taproot is relatively small and slender but the side roots are large. They tend to lie near the surface of the ground. Fortunately for the survival of slash seedlings the root is not so attractive food for hogs as that of longleaf pine.

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REPRODUCTION

Slash pine reproduces abundantly under normal conditions. It establishes itself most readily in wet sites where there is less danger from fire. It is not so resistant as longleaf pine to fire, especially during its early life.

Seed may be collected for planting purposes as is indicated in the discussion of this subject under longleaf pine (p. 118).

OLEORESIN CONTENT

An examination of the wood of a number of specimens of young unturpentined slash pine showed that it contained a varying amount of resinous material (ether extract). The outer sapwood was found to yield 1.63 to 4.81 percent, the intermediate rings had a slightly higher content, and the rings at center, in some cases incipient heartwood, contained from 3.4 to 21.6 percent. An average from composite samples of material from about 60 trees ranged from 2.5 to 3.3 percent. The amount of resinous material and also the so-called "unsaponifiable matter", of which resene found in rosin is an example, was notably largest at the center of the trunk. A higher resinous content was found in open-spaced rapidly growing trees than in those which came from denser stands with slower growth (*334*).

IMPORTANCE OF THE SPECIES

NAVAL STORES PRODUCTION

Slash pine as a producer of naval stores is in high favor both because it gives relatively high yields (*98*) and because the gum is ordinarily more liquid and forms relatively less scrape (p. 72) than longleaf gum. For these reasons and because the species seems to be spreading and now under increasing fire protection makes up a larger proportion of second-growth stands than it did of the original forests, it is held that slash pine will play an increasingly large part in the production of naval stores in the United States.

LUMBER PRODUCTION

Slash pine is capable of supplying the lumber market with strong material, and is already doing so to a considerable extent together with the other southern pines. Slash pine produces under proper growth conditions one of the heaviest, hardest, and strongest woods of all the commercial conifers in the United States (*386*). This heavy wood contains as a rule a high proportion of dense summerwood fibers (p. 28). For the strength characteristics of the wood see table 4.

PULP PRODUCTION

Slash pine wood is well adapted for pulp and southern pulp mills take it readily along with that of other pines. Both the sapwood and the heartwood are used in the manufacture of kraft paper. The fact that young slash saplings contain no heartwood, that heartwood

often does not develop until they are about 20 to 25 years old, and that the sapwood shows a relatively low resin content (*291*, *402*), has led to tests now in progress to determine the adaptability of this wood for sulphite and ground-wood pulps to be used in book, writing papers, and newsprint. Slash pine has already been successfully manufactured at the Forest Products Laboratory (*45*, *46*) into white book paper by the sulphate process, and experiments on a small scale have given promising results with the other processes.

When discussing this species in 1893, Fernow (*195*, *402*) states that though slash pine sometimes yields more resin than longleaf pine, fallen logs and stumps do not become pitchy throughout, or as the saying is, turn into lightwood, although such behavior is characteristic of longleaf pine. As yet Fernow's observation on slash pine has not been fully confirmed.

OTHER SOUTHERN PINES

In the United States it is not customary to turpentine on a commercial scale other species of southern pines besides longleaf and slash. There have been in the past, however, occasionally instances of small workings in stands of loblolly pine (*Pinus taeda* Linnaeus) (*41*, *42*, *130*, *139*, *378*), which may somewhat resemble slash pine externally, and in stands of shortleaf pine (*Pinus echinata* Miller [9]) (*160*, *161*, *373*, *374*, *375*, *376*, *385*). Both species, however, are held to require more frequent chipping than is profitable in proportion to the yield of gum obtained. Information concerning the distinguishing characteristics of the principal southern pines is given in table 4.

Other pines also grow in the Southeastern States. One of these is Sonderegger pine (*Pinus sondereggerii* H. H. Chapman) which is believed to be a hybrid between longleaf and loblolly pine. It is reputed to be of rapid growth, and to be capable of producing gum for naval stores. This tree has been reported as growing in Louisiana and southern Texas but is at present of little commercial significance (*129*).

Pond pine (*Pinus rigida serotina* (Michaux) Loudon) is also sometimes turpentined but its gum differs in composition from that of slash and longleaf pines (*292*). Sand pine (*P. clausa* (Engelmann) Sargent) and spruce pine (*P. glabra* Walter) also occur. The latter three species are readily distinguished from longleaf and slash pines by their shorter needles and other external characters.

WESTERN PINES [10]

None of the pines that grow in the Western States is at present used to any considerable extent commercially for naval stores production. It has been demonstrated, however, that it is possible to obtain a considerable yield of naval stores from ponderosa pine (*Pinus ponderosa* Lawson).

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[9] Formerly called *Pinus mitis* Michaux. The name "shortleaf" is also applied in some localities to loblolly pine.

[10] Compiled by Eloise Gerry, Forest Products Laboratory, with the advice and assistance of C. L. Hill, California Forest Experiment Station, Forest Service.

PONDEROSA PINE

During the period of the Civil War, when the supply of naval stores from the South was cut off, an attempt was made to supply the Northern States from the pines of the Sierra Nevada Range of California. At least three distilleries were established and one company tapped more than 20,000 trees. The industry, however, lapsed into insignificance as soon as the southern product again became available.

In more recent years tests carefully conducted on the western national forests by the Federal Government have shown the yielding possibilities of the western pines when tapped by modern conservative methods (*64, 396, 494*). Turpentine leases covering the working of Government timber on the national forests in Arizona have also been offered for sale to the public at a time when supplies of southern timber appeared to be dwindling rapidly in some areas.

Ponderosa pine, particularly that which grows in the Southwestern States, is the most promising yielder of gum among the western species. It is also one of the most abundant and most widely distributed western softwoods of commercial importance (*510, 512*). It develops into a large tree 3 to 6 feet in diameter and 125 to 175 feet in height, sometimes even reaching a maximum diameter of 10 feet and a height of 240 feet. The young trees are known as "blackjacks" because of their blackish, deeply furrowed bark, and dense crowns, which characteristics are often maintained until the trees are more than 100 years of age. Ponderosa pine in California, especially when mature, is difficult to distinguish from the Jeffrey pine associated with it in the forest. The only positive distinction now known is the absence of heptane in the distillate of the ponderosa pine. Older ponderosa pines have a reddish-brown bark fading in old age to a light tan. Freshly exposed bark scales usually have a sulphur-yellow color as compared with the gray of Jeffrey pine. The bark may often be 3 or 4 inches thick, especially near the base of the tree (*510*). Its volume may amount to 20 to 30 percent of the volume of the wood. Ponderosa pine produces some seed every year but heavy seed production may occur only once in 6 or 7 years. The trees are long-lived, attaining an age of 350 to 500 years (*33, 173*).

The turpentine and rosin produced from the gum of ponderosa pine differ somewhat in physical and chemical properties from those of the southern pines but have been found satisfactory for ordinary commercial use. The gum from ponderosa pine contains about 78 percent of rosin and 22 percent of turpentine (*64, 470*). Great care is required in distinguishing the ponderosa pine trees that are to be turpentined from the Jeffrey pines, since because of its different chemical composition, the inclusion of any Jeffrey pine gum is equivalent to adulterating the ponderosa pine gum. One of the easiest and most reliable, although not absolutely conclusive, means of distinguishing the two is the odor of wood, bark, and gum when a small cut is made into a tree. If the exuding gum has the characteristic turpentine odor of pine, it is ponderosa pine. The gum

of the Jeffrey pine has an entirely different and rather pleasing aromatic odor which suggests that of pineapple or of vanilla. Trees have been found that yielded gum with the described odor for Jeffrey pine, but on distillation the exudate was found to contain turpentine, and hence the trees were classed as ponderosa pines (*397*).

The recorded yields of gum from ponderosa pine may in some cases be higher per cup per week than the average of those from the southern pines, but the seasonal yield is usually less, due partly to the shorter working season at the high elevations where these western pines grow. There is also, as yet, no experienced labor, accustomed to carrying on the process of turpentining, available in the Southwestern States (*64*, *396*, *494*).

HEPTANE-YIELDING WESTERN PINES

Two species of western pines, Jeffrey pine (*Pinus jeffreyi* Oreg. Com.), which very closely resembles ponderosa pine in structure and appearance, and Digger pine (*P. sabiniana* Douglas), which is easily distinguished from the other pines, contain heptane in their oleoresinous exudate. Heptane, whose chemical formula is C_7H_{16}, is a hydrocarbon also found in petroleum; but existing as far as is known in only three plants. These are the two pines just referred to and a Philippine hardwood tree, *Pittosporum resiniferum* Hemsl (*67*, *199*, *243*, *328*, *329*, *330*, *331*, *332*, *440*, *461*, *462*, *466*, *470*, *472*, *473*, *483*, *484*, *515*, *549*, *550*).

When heptane is present in pine gum it appears to be in place of the turpentine found in other pine species. Thus far turpentine and heptane have been found only once mixed in the same tree (*395*). The crude distillate of the gum of these pines was early known as "abietene" and has been used locally in California as a cleansing agent, an insecticide, and as a constituent of chewing gum, cough sirups, and other medicinal preparations. That 96 percent of abietene was heptane was discovered about 1879 (*461*, *462*). A recent new use has arisen for heptane as a constituent of a standard fuel for the measurement of detonation in internal combustion engines (*182*, *304*). This use has led to a small commercial production of the gum of Jeffrey and Digger pines in California.

OTHER WESTERN SPECIES

Experiments in turpentining have been made on other western species. The species include the piñon pine (*Pinus edulis* Engelmann), which when turpentined in Colorado yielded less gum of slightly different composition from that of ponderosa pine. Sugar pine (*P. lambertiana* Douglas) and lodgepole pine (*P. contorta* Loudon) were also turpentined but produced small yields (*64*, *494*).

Detailed information may be obtained from the accompanying list of references on the western pines (*6*, *61*, *137*, *251*, *404*, *510*, *512*, *562*), their silviculture (*324*, *327*, *424*, *425*, *539*), enemies (*68*, *325*, *393*, *503*), and utilization (*486*, *487*, *561*).

OLEORESIN AND ITS OCCURRENCE IN THE TREE [11]

THE NATURE OF OLEORESIN OR GUM

The gum, or oleoresin, that exudes from the wood of slash or longleaf pine when a cut is made through the bark into the outer woody layers (fig. 8) comes from groups of living cells that surround the resin passages. Gum consists chiefly of a mixture of resinous acids and an essential oil (turpentine) composed of varying proportions of carbon, hydrogen, and oxygen. It also contains small but important quantities of sugarlike, water-soluble materials

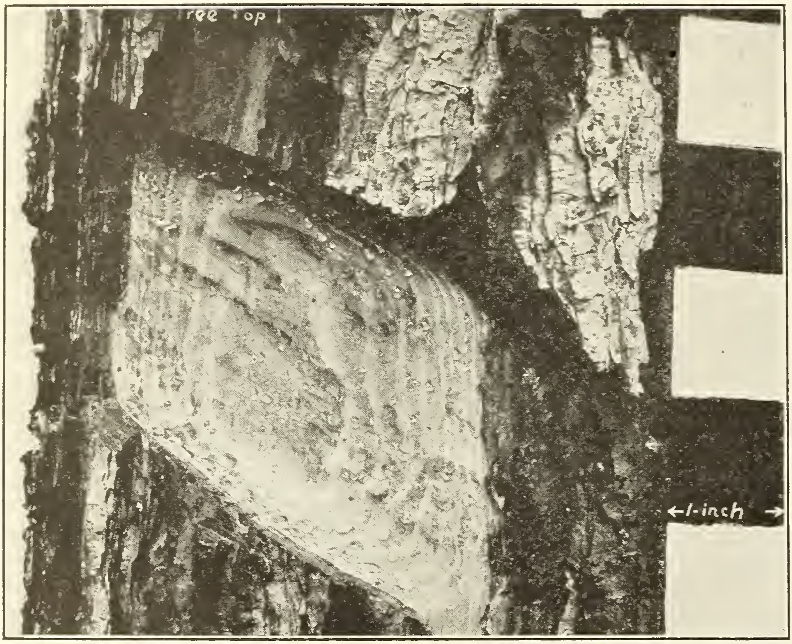


FIGURE 8.—Condition 5 minutes after a fresh cut had been made into the wood of an unturpentined pine. Note droplets exuding from ends of vertical resin passages. (Rule marked in black-and-white inch squares at right.)

which appear to be closely connected with the process of gum production and distinctly affect rosin color if the gum is carelessly handled (*260*). These water-soluble materials do not refer to trash or other material washed off the tree, but to the water-soluble materials contained in the gum itself.

The gum is not what is generally termed the sap of the tree. The sap is a watery solution that moves chiefly through other cells than those from which the gum exudes (fig. 9).

There is a tendency to consider the process of obtaining pine gum—turpentining—analagous to the tapping of maple trees for their sap. In the case of the maple trees, however, the operator actually for a short period in the spring "bleeds" the tree of its sap. This is at the time when the watery sap of the maples contains dissolved in it considerable amounts of sugar. This sugar comes from the products the tree thriftily stored away the summer before. Very

[11] Eloise Gerry, Forest Products Laboratory.

soon this sugar content is changed and the sap is no longer "sweet enough" to make good sirup. That is, the business of collecting is limited by the tree's chemistry to a brief season. In the pines, on the contrary, the exudation of gum increases as the growing season advances, when the tree's ability to make foods from air, water, and soil constituents in the presence of sunlight (photosynthetic activity) is at a maximum.

The pine sap in spring, like that of maple trees, also contains some sugars and other compounds formed from the materials that were

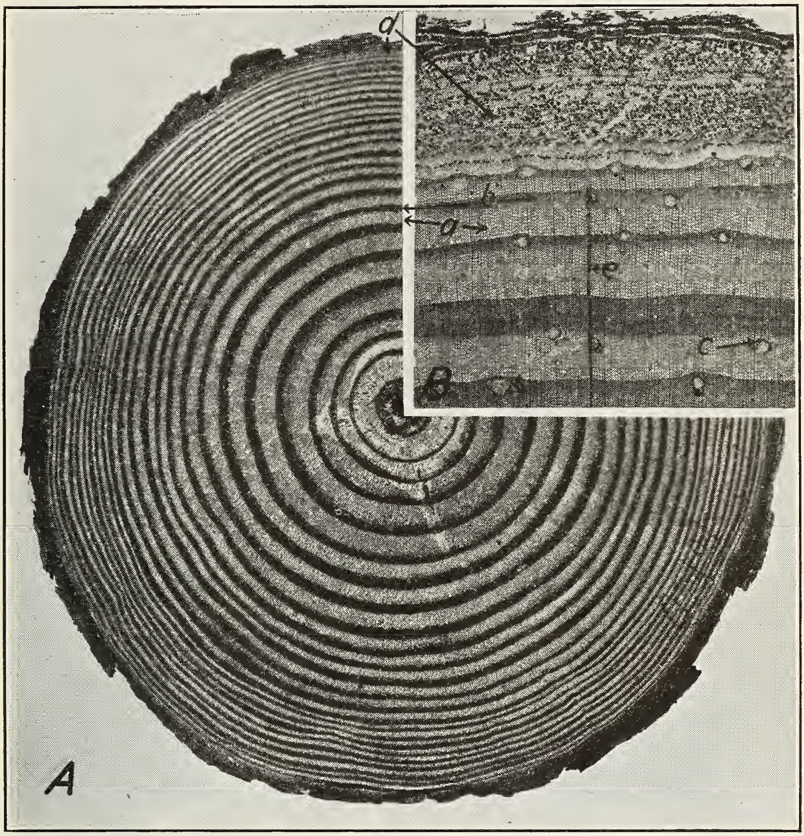


FIGURE 9.—*A,* Disk of pine wood. *B,* An enlarged area of same as seen under the microscope: *a,* Spring wood; *b,* summer wood; *c,* parenchyma cells surrounding a resin passage; *d,* inner bark or phloem with stored food reserves (black); *e,* ray connecting two resin passages and the phloem.

stored up in excess of what was used during the activities of the previous season. It is not this watery sap, however, that the turpentine operator collects and distills. He does not bleed the tree for its sap. The sugars and similar compounds that are stored in pine trees lie more or less inert in the tree during the cool winter days. They are used, however, for the growth of the tree when the warm weather comes in early spring. It is the circulation and utilization of these materials by the tree that characterizes the season when it is said that "the sap is up." They serve to form the pollen, leaves, wood cells, and the gum that is collected when the tree is chipped (*204*).

INTERNAL STRUCTURE OF UNTURPENTINED PINES

OCCURRENCE OF GUM-YIELDING TISSUES

In longleaf and slash pines, gum-yielding tissues are made up of what are known as parenchyma cells. These occur in roots, leaves

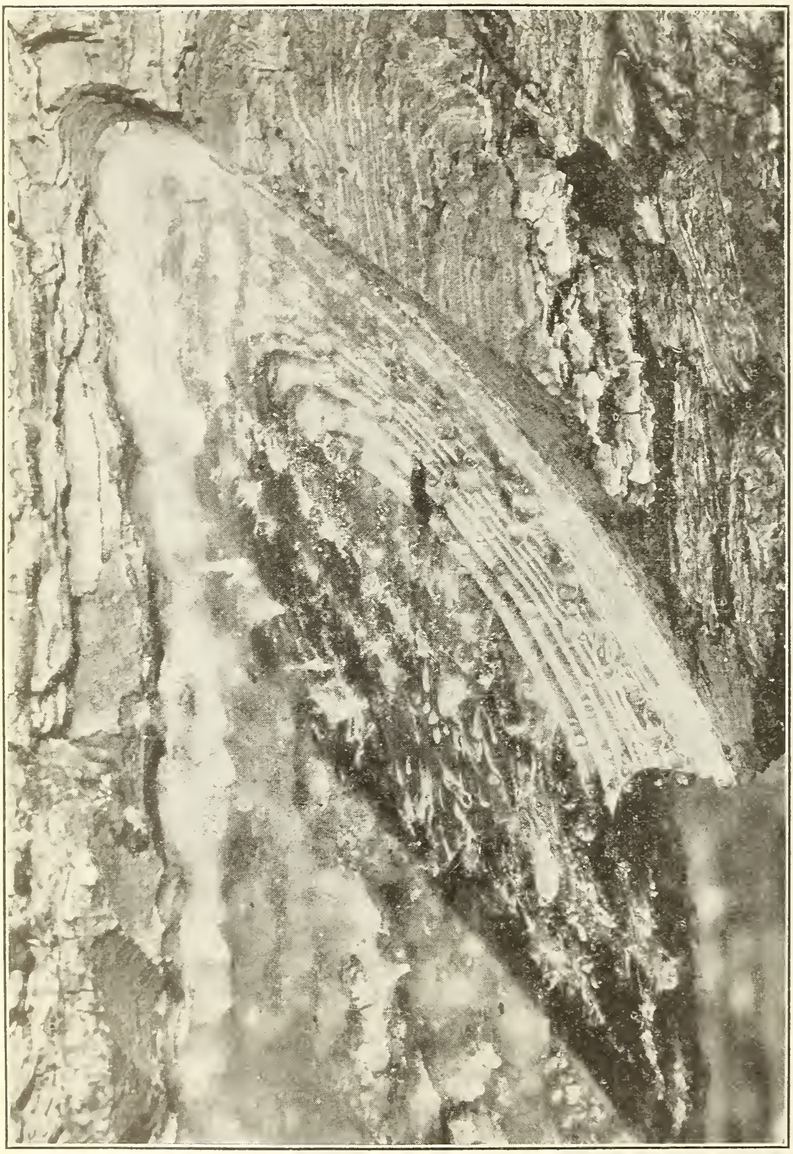
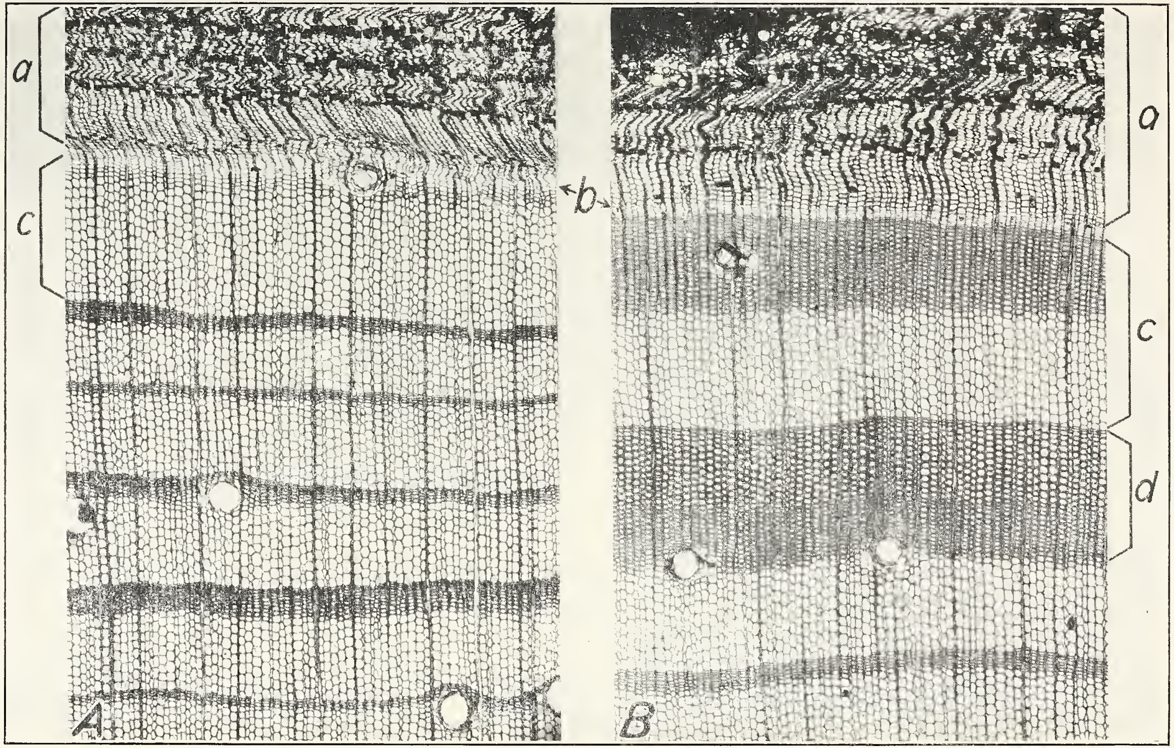


FIGURE 10.—Gum exuding from a deeply chipped streak or wound on a turpentined pine.

(*51*, *225*), and inner bark as well as in the wood of the stem from which the exudation is obtained in commercial turpentining. The parenchyma cells are shorter than the wood fibers (p. 30), which



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HIGHLY MAGNIFIED CROSS SECTIONS OF LONGLEAF PINE.

A, *a*, Inner bark; *b*, cambium; *c*, partly completed annual ring with newly formed resin passage and summer wood barely beginning to form. *B*, *a*, Inner bark; *b*, cambium; *c*, a completed annual ring with summer wood next the cambium; *d*, zones of summer wood cells with walls of varying thickness.

conduct the water solutions absorbed by the roots. The parenchyma cells live longer than the other wood cells. They are particularly active in the outer part of the wood next the bark. These cells contain protoplasm, the substance by means of which living cells carry on their complex functions, such as absorption and transformation of the materials that enter them (*523*). The gum that collects in the cups on turpentined pines is a product of the activities of these living cells. Where a group of these cells (often called

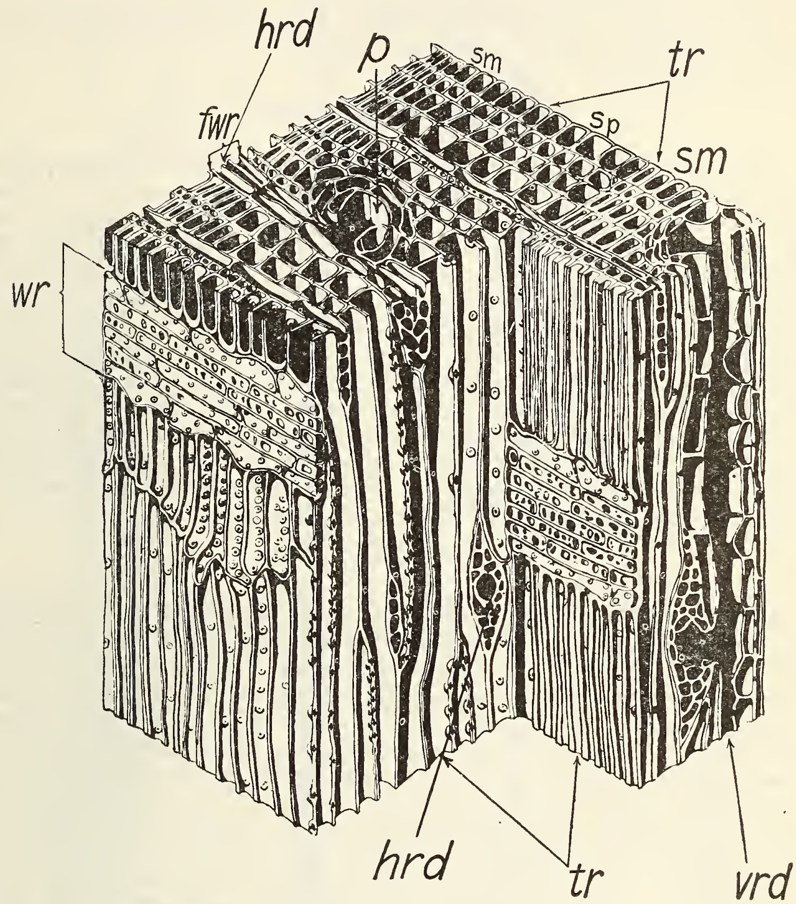


FIGURE 11.—A diagrammatic representation of pine wood: *tr*. Sap-conducting cells or fibers; *vrd*, vertical resin passage; *hrd*, horizontal resin passage in *fwr*, fusiform wood ray; *p*, parenchyma cells; *wr*, rays; *sp*, spring wood; *sm*, summer wood.

epithelial cells) separates at the center, a resin passage, or so-called "resin duct", is formed. The droplets of gum shown in figure 10 along the fresh cut made in the wood have exuded directly from such passages. Illustrations of these structures are shown in the somewhat diagrammatic and idealized representation of a magnified block of pine wood in figure 11. The two systems of resin passages, the vertical (*vrd*) and the horizontal (*hrd*) are represented in figure 11 as they appear on both cross and lengthwise sections of the wood.

The fact that the two systems are connected with each other is illustrated in the lower right-hand corner of figure 11. The actual appearance and distribution of the vertical resin passages, as seen through the microscope on a cross section from a young long-leaf pine tree, is shown in figure 9. Here also near the center of the enlarged picture the connection of the two systems of resin passages is illustrated by the heavy dark line (*e*), which is a horizontal resin passage connecting two separate vertical resin passages in different annual growth rings.

Tissues capable of yielding gum are present in the round timber in all slash and longleaf pine trees, even if they have not been turpentined (fig. 8).

NORMAL GROWTH OF PINE TREES

While longleaf and slash pines are alive, they continue during the warmer parts of each year to manufacture new materials in their leaves. These are circulated through the inner bark, or phloem, and the outer wood of the tree, the sapwood. They serve to increase the size of the tree and also its supply of stored reserve products upon which it can draw at seasons when growing conditions are unfavorable or when the tree activities are dormant and do not furnish adequate new supplies. The new growth each year, recognizable in the wood as the outermost annual ring (p. 28), takes place throughout the entire tree on both roots and stems, which are covered with a layer of new wood and phloem, introduced between the old wood and bark. In addition, the tree adds new growth (fig. 12) to the length of roots and shoots at the tips of the old ones and prepares the buds that give the next year's leaves and seeds.

CAMBIUM

Between the wood and the bark is a very thin layer of cells, called the cambium (pl. 1). It is here that the new wood and bark cells are formed each growing season by the division of the cells of the cambium, which are themselves neither wood nor bark. The cambial cells are spoken of as being undifferentiated or embryonic tissue, that is, they have not clearly developed the characteristics that are considered peculiar to either wood or bark, but are capable of growth into cells that can become the one or the other. These little cells, or their descendants, so small that they are invisible to the naked eye, live indefinitely, so that if no accident happens to a tree it may live for centuries. When this layer of thin delicate cells is active, swollen, and full of moisture, it makes a very weak bond between the bark and the wood so that the bark slips and logs, poles, or pulpwood may then be most easily peeled. The gum does not exude from the cambium. The function of the cambium is to build cells which when they are fully formed take part in sap conduction or in gum formation.

ANNUAL RINGS

The layer of new wood added over their entire surface each year by such pines as slash and longleaf, is called an annual ring (fig. 9). At the top of the tree this layer is extended upward so that the

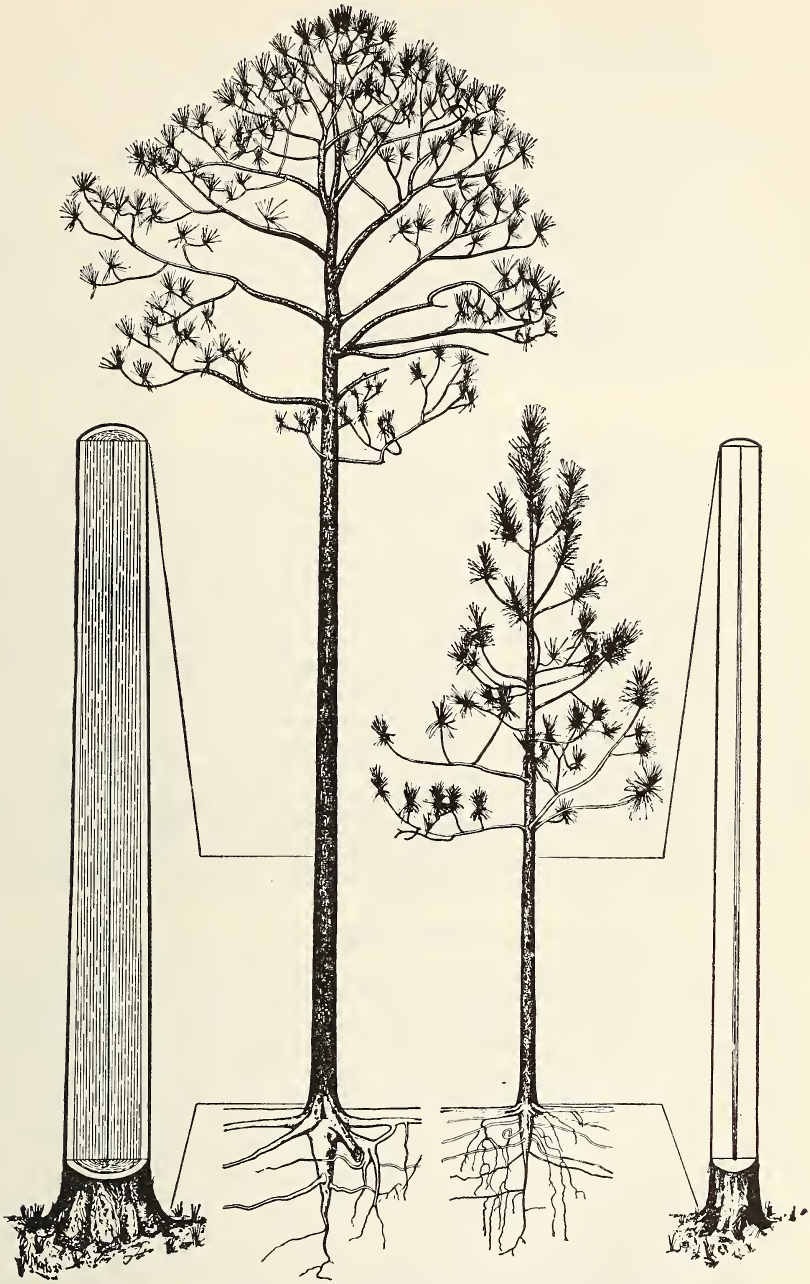


FIGURE 12.—Diagrammatic sketch of a young and a mature southern yellow pine showing relative amounts of heartwood (shaded area at center of trunk) and sapwood.

young growing tip made up only of the current season's growth, increases the height of the tree, while at the same time further down the new layer covers the ring of the year before over the entire trunk, branches, and roots of the tree. A tree is really made up of hollow cones one overlaying the other. At about the same time that the new layer of wood is formed on the outside of the old wood, a new layer of bark is formed on the inside of the old bark. The annual rings of bark, however, are not so easy to see as the rings of the wood, which are a familiar sight in lumber and can be counted on the smooth-cut surface of almost any sound stump. Annual rings are often referred to as the "grain" or "grains" of the wood. The number of annual rings in an inch (measured across the rings) is commonly used in describing the rate of growth of timber, in determining its properties as lumber or structural timber, and can also serve as a guide in the living tree for estimating its probable yielding value for turpentining.

SPRING WOOD

The annual rings in slash and longleaf pine are very clearly divided into two regions, the spring wood and the summer wood. The spring, or early wood, is that first formed each year (fig. 9). It is the lighter colored part of the ring; the walls of its cells are thin, and where a large proportion of it is present the wood is comparatively light in color and weight and is relatively weak. The time of the beginning of spring-wood formation varies in different parts of the southern pine region, but it closely parallels the extension of the candles, or leaf buds, beginning generally in March or April and usually being well completed by May or June.

Gum passages in round, or unturpentined, timber are much less frequent in the spring wood than in the summer wood. The great part of them begin to form about the time that spring-wood formation ceases and summer-wood cells begin to develop. The spring wood above the face of a turpentined tree, however, differs from that in unturpentined timber, for often many gum passages form there in the region of the turpentine face as the result of the wounding (p. 33).

SUMMER WOOD

The dense, dark part of the annual ring begins to form rather suddenly in slash and longleaf pine (fig. 9). There is generally a less gradual change from thin-walled spring-wood cells to thick-walled summer-wood cells than is found in many other species. The development and thickening of the summer wood lasts from May or June till November, December, or perhaps even January or later in very mild winters. Wood formation is often retarded early in the season by long periods of dry or cold weather. When a period of rainy, mild weather comes late in autumn, the apparently almost completed summer-wood formation may be taken up again with fresh energy. Sometimes a few rows of cells resembling spring wood may form before summer-wood growth is resumed, producing the so-called false annual ring. This, however, usually can be recognized, for the lines of demarcation on such rings are less sharp than at the boundary of true annual rings. Further, the last rows of

summer-wood cells that form after such weather frequently, at least at first, appear slightly different in color from the old summer-wood cells, so that they make noticeable zones. When microscopic sections of such trees are prepared and artificially dyed or stained to make the microscopic structures more conspicuous, these zones take up the dye differently and appear different in color from the rest of the summer wood (pl. 1, *d*).

It is in or near the summer wood that most of the resin passages are found in ordinary unturpentined pine wood. The gum from the resin-forming tissues tends, to some extent, to enter the cell walls, especially of the summer-wood cells, and plays a part in making them appear dark in color in dry-faced trees and particularly in pine heartwood. The percentage of summer wood (*356*) in a given pine timber serves as an indication of its density and strength, and the structural-timber grading rules for southern yellow pine, including slash and longleaf, contain specifications based on this characteristic (p. 111).

PERIOD OF NO WOOD FORMATION

During December, January, February, and March, depending on the locality and the weather, the tree usually is not active in building new wood cells in the main trunk. This time of inactivity is often called the dormant period. It is that time when woodsmen are inclined to say "the sap is down". It appears to be true, however, that there is actually no less moisture at this time in wood (*145*, *146*, *147*, *232*, *233*) but rather a reduced chemical activity in the living cells in the tree, which may be due, at least in part, to the lower temperatures prevailing during these months. Weekly chipping during this period is unprofitable for the gum flow is less rapid and a longer period between chippings must elapse to obtain the full exudation from each streak. Chipping about once in 4 weeks, however, during warm periods in winter has often been found to yield a fair return, although it may often cause a later reduction in yields as a result of overtaxing the trees.

RAYS

In all the southern pines there are two kinds of rays, or horizontal bands of cells, which extend from the bark toward the center of the tree. They are so small that the largest are barely visible without a microscope. They cross at right angles the many vertical cells (fibers or tracheids) which serve to conduct the watery sap of the tree. Whereas the fibers may be many times as long as they are wide, the ray cells are comparatively short and roughly may be considered brick-shaped (fig. 11). The rays are of two kinds, known respectively as linear rays, which are one cell wide, and fusiform rays (figs. 9 and 11), which are more than one cell wide especially at the center where they contain a horizontal resin passage. Although small, the rays are very numerous. In a study of southern pine wood, probably longleaf, it was found that on a flat-sawed, or tangential, surface of the wood there were about 15,000 linear rays and about 300 to 400 fusiform rays per square inch (*402*). A similar microscopical examination of young unturpentined slash

pine from Georgia showed a distribution on flat-sawed wood of about 20,000 linear rays and from 245 to 819 fusiform rays per square inch (*298*). The abundance of the rays interwoven throughout the conducting cells of the wood and the bark is indicative of their significance in the life processes of the trees.

The rays serve to conduct the food material, produced by the leaves, from the phloem into the cambium, where new cells are forming, and also into the outer annual rings or sapwood of the tree. The rays may also store reserve supplies which are utilized in emergencies, such as when the leaves of the tree are destroyed by fire and consequently cannot supply the materials needed for growth. These reserves undoubtedly also play a part in the formation of gum in response to the wound of chipping in the process of turpentining and probably in the transformation of sapwood into heartwood.

The relative size of the small resin passages occurring in the fusiform rays and the large vertical resin passages with which they connect is shown in figure 11. When scrape is collected and the scrape iron exposes a smooth freshly cut surface of the wood, the tiny beads of gum may be seen exuding from each fusiform ray resin passage that has been opened by being cut across. The relative sizes of these droplets and of the drops that exude from the vertical resin ducts cut across at the streaks (fig. 8) indicate the relative sizes of these two resin-passage systems. This same relationship is shown by each fresh chipping by the French method (p. 149), which opens up both systems of resin passages. The reopening of horizontal resin passages by the French type of chipping may have some bearing on the relatively higher yields that have sometimes been secured from such faces when their total width is equivalent to that of American faces.

WOOD FIBERS

When pine wood is converted into pulp for making paper most of the pulp is made up of fibers, which are the long sap-conducting cells shown at *tr* in figure 11. These fibers are longer in longleaf and slash pine than in many other woods. The length of the mature fibers in longleaf pine, including wood from both stems and roots, ranges from 0.68 to 7.20 mm, an average of about 3,100 measurements being 3.70 mm, or about 0.15 inch. The length of the fibers alone, however, does not give assurance that the wood is either strong for lumber uses or a perfectly satisfactory wood for pulp making. Other qualities are necessary; for instance, the proportion of the fibers that have thick walls and constitute the summer wood gives an immediate indication of some of the properties that make these woods so highly valued for structural purposes. The amount of summer-wood fibers present in pulpwood, on the other hand, may require special pulping methods to obtain the best yield because of wastes resulting from screenings made up of bunches of imperfectly digested summer-wood cells. The very length of the fibers of pines at first seemed a disadvantage in papermaking, instead of the advantage expected, for the fibers were not so flexible as those of some other woods and did not mat together well to form a sheet of paper. Such behavior, however, has been largely over-

come by proper treatment of the pulps in the kraft-paper industry and the inherent characteristics of the material may be shown to be of advantage when a better understanding of methods of treating it is obtained.

The fibers in pines, as in all conifers, are characterized by having thin areas, or bordered pits, on their cell walls. It is through these pits that the sap circulates in the living tree. These pits also affect the penetration of wood by preservatives as well as the passage of the chemical solutions used for separating the fibers when the wood is made into paper pulp.

The fibers serve two purposes in the living tree: (1) They are the channels through which the sap is conducted, and (2) they are the strength-giving elements that support the crown of the tree. The strength and elasticity of these fibers are important factors in enabling the trees to withstand winds. Single fibers are visible to the naked eye if a piece of paper is torn and the frayed edge held against the light.

New fibers are formed each year by the division of their mother cells in the cambium. They do not remain alive very long, however, because as soon as their walls have become thickened and finished, these cells lose their protoplasmic content and become dead cells. They continue to function, however, in the process of sap conduction where they may be likened to the water pipes in a house. The life history of the fibers differs from that of the parenchyma cells, which remain alive for years (p. 24). In turpentined trees a larger than normal number of parenchyma cells may be developed at the expense of wood-fiber formation in the region above the face.

SAPWOOD

In young pine seedlings the wood of the stem is all sapwood (fig. 12). This wood contains living cells capable of storing starch and other reserve foods and converting them into new compounds used in building wood cells and gum. The sap circulates through the cavities of the sapwood cells which serve as conducting tissue between the roots and the leaves. Chemical analyses made of the sapwood show that in both longleaf and slash pine the gum content is relatively low (pp. 12, 18). This determination is usually based on the amount of material that can be extracted from sawdust with ether or some other solvent. If a cut is made into the outer layers of the sapwood, a large volume of gum may exude. The tree is to be regarded, however, rather as a factory than as a reservoir, for the gum is not merely stored within; it is produced through the activities of living cells, which generally are stimulated to more than ordinary gum production as a result of the wounds or cuts made in turpentining.

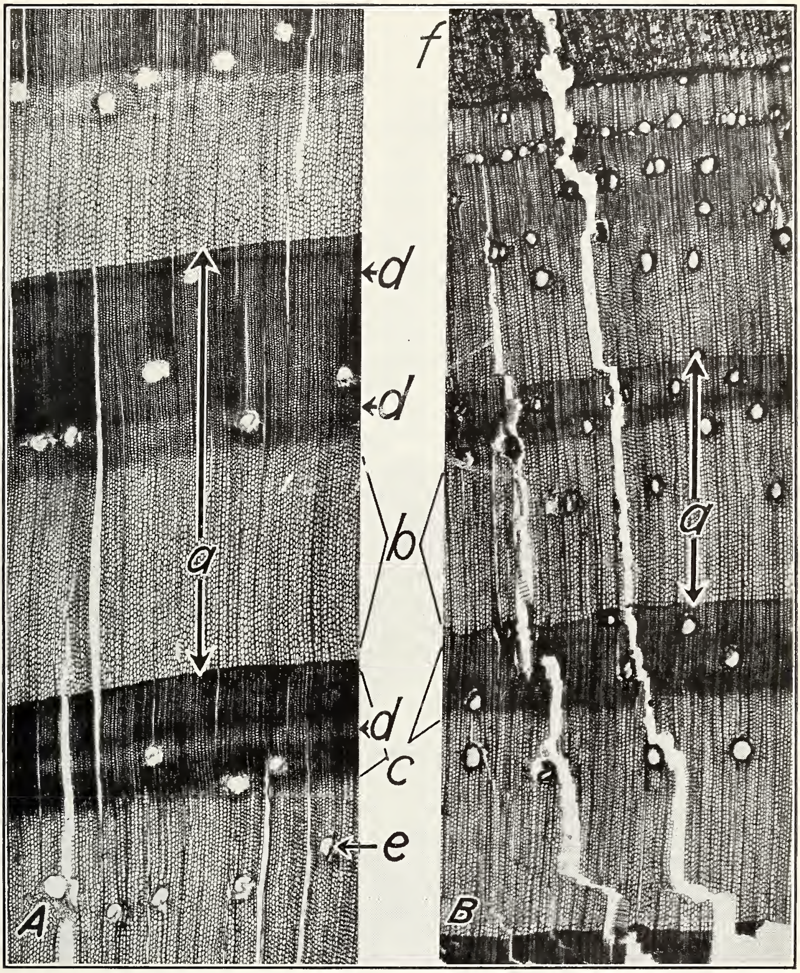
The width of the sapwood varies in different trees. The whole of a 20-year-old tree 6 to 7 inches or more in diameter may be sapwood, or again in old, slow-growing trees the sapwood may be only an inch wide or even less. The gum in the sapwood appears to be in a more liquid condition than that occurring farther inside the tree in normal or in incipient heartwood. The most vigorous large-topped trees usually have the widest sapwood. Trees with narrow sapwood have to be turpentined with shallow cuts or streaks,

for otherwise they fail to yield gum, become dry faced (p. 63), and may even die, since the best health of the tree depends upon its sap-conducting activities and requires that a layer of healthy, moist sapwood be maintained behind the turpentined face. The sapwood is usually somewhat lighter in color than the heartwood. When cut into lumber, ties, or posts it decays more readily than heartwood, but it can also be penetrated more easily, and therefore treated more easily with preservatives to prevent decay or impregnated with the chemicals used in making chemical pulps. From year to year, after the pine trees are 15 to 30 years old, the inner annual rings of the sapwood are gradually transformed into heartwood.

HEARTWOOD

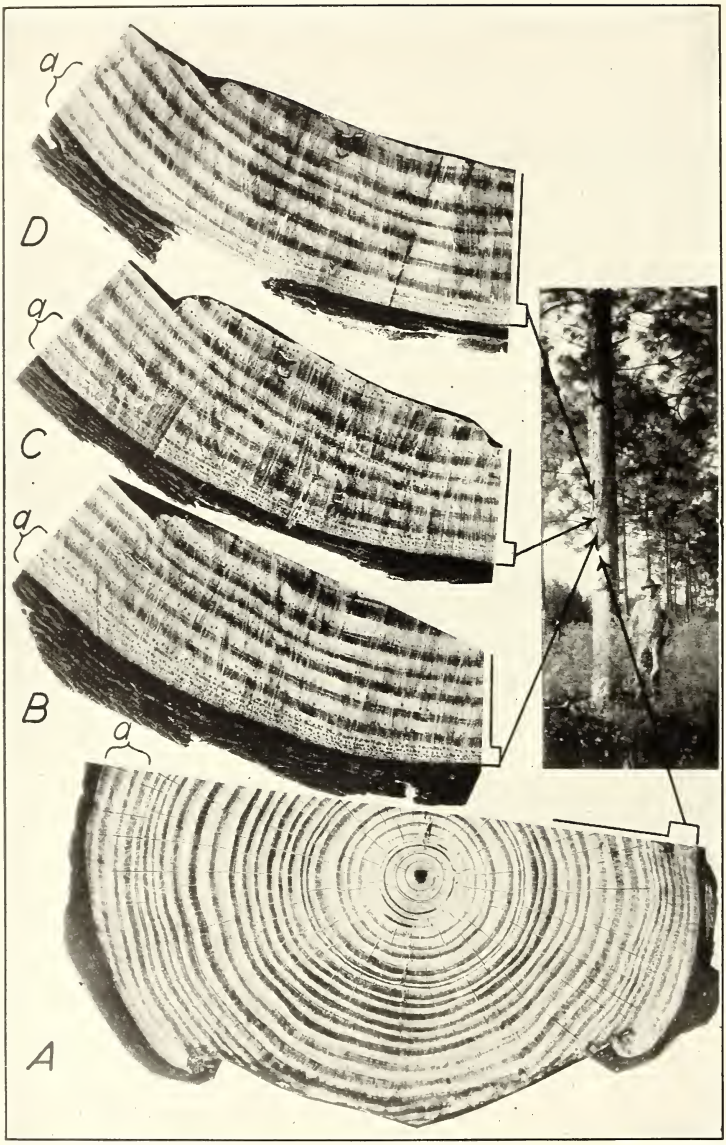
The heartwood in any tree was sapwood during the earlier years of the tree's life (*417*, *435*). The heartwood does not as a rule contain living cells, and there is no evidence of active circulation of sap through its channels. The functions of heartwood, though not fully understood, appear to be passive rather than active. The strength furnished by the column of heartwood at the center of the tree helps to hold up the weight of the actively functioning crown of leaves (fig. 12). The heartwood, it is believed, may also contain moisture and gases that are capable of diffusing into the sapwood under certain conditions. The heartwood of slash and longleaf pines contains a greater amount of resinous material than the sapwood, and this resin is in a different, less liquid, condition than that in the sapwood (*402*). The appearance of the stump of a freshly felled mature pine is a familiar illustration of this condition. Beads of resin exude all over the sapwood from its numerous resin passages, and they flow together, coating the sapwood area. None, however, exudes from the equally abundant resin passages in the heartwood, so that the line of demarcation between heartwood and sapwood is clearly evident. The heartwood area is also somewhat darker in color than the sapwood, and in very resinous trees may appear almost translucent if a thin layer is held against the light. This type of material is highly valued for the production of wood-distillation products by either the destructive or solvent distillation processes (*499*). The stumps of large, old trees are used by these industries, and they are generally not harvested until 8 years or more after the trees have been felled. During this time the sapwood is generally completely destroyed by decay, so that only the more resinous heartwood, with its projecting lightwood knots, remains. The heartwood of slash and longleaf pine is more durable than the sapwood if used untreated.

It is the lumber cut from heartwood that has in the past made southern pine so highly favored for many uses. The wood from the young second-growth trees is more largely sapwood (fig. 12) and is frequently of faster growth, so that it has a coarser texture; but this vigor of growth makes it an excellent yielder of naval stores. It is possible to produce pine wood of the same character as the old narrow-ringed virgin pine heartwood, but it takes so many years that it now appears impracticable on a large scale. It is therefore important to understand and use the second-growth trees to best advantage (p. 110).



MAGNIFIED CROSS SECTIONS OF YOUNG SLASH PINE.

A, Wood formed before the tree was turpentined. *B*, Wood formed above the face after turpentining; *a*, annual ring; *b*, spring wood; *c*, summer wood; *d*, thin-walled zones; *e*, resin passage; *f*, inner bark. Note narrower annual ring with less summer wood but more resin passages in *B*, *a* compared with *A*, *a*.



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THE NUMBER OF RESIN PASSAGES DECREASES WITH INCREASE IN DISTANCE ABOVE THE FACE.

A, Block cut at the top of the face, considerably reduced in size. *B*, Block cut 3 inches above and to the left of the peak and extending toward the side of the face. The resin passages present appear as conspicuous black dots and are numerous in wood formed after turpentining began, *a*. *C*, Block cut 1 foot above *B*. Only about one-half as many resin passages were present in a given portion of the rings of the area *a* as were found in the *B* block. *D*, Block cut 1½ feet above *B*. Only about one-third as many resin passages were present as in *B* in the rings in a similar portion of *a*. About one-fourth as many resin passages were found in a similar portion of the normal wood as in the rings of the area selected in block *B*.

Since no resin is drained from the heartwood, turpentining does not affect the strength or resin content of the heartwood. Moreover, in the neighborhood of the face, turpentining tends to increase the resin content of the sapwood, which may later become heartwood, so that turpentining itself does not make the wood less durable if properly done and if the woods are protected from fire damage.

INNER BARK

Each year, the cambium layer of normal slash and longleaf pine builds a layer of wood at its inner boundary and a layer of soft inner bark, or phloem, at its outer boundary. This phloem is illustrated in figure 9 and plate 1. It is visible to the naked eye, especially in spring, when it is comparatively wide and appears white at the surface of a freshly cut streak. The phloem is often mistaken for the cambium which, however, is not visible to the naked eye. The phloem is made up of parenchyma cells (vertically extended) and rays (horizontal parenchyma), the activities of which are of primary significance in gum formation. The conducting cells of the phloem, corresponding to the fibers of the wood, are called sieve tubes. Through the sieve tubes pass the products manufactured by the leaves and used by the tree in building new tissues and storing reserve supplies. In slash and longleaf pines this tissue is very rich in tannin and other complex organic compounds, including enzymes. The presence of large quantities of starch can, for example, be demonstrated easily, especially in early spring, in the phloem parenchyma of thrifty pine trees. The starch turns blue if iodine is dropped on the surface of the phloem tissue. The complex chemical reactions conducted by the living cells of the phloem are little understood and offer an important field for investigations now in progress on the factors that influence gum production by the tree.

Indications that the trees are being damaged by turpentining and are likely to dry-face may be observed in their early stages by examining the phloem layer exposed at the streak (p. 63). In dry-faced trees this becomes pitch soaked and collapses, failing to serve in the conduction and transformation of materials required to maintain vital processes (*442*, *443*, *514*). The difference in the phloem and its content in trees with large and small crowns, respectively, demonstrates the correlation between the activities of this tissue and growth responses. The lack of stored content and the poor development of the phloem cells in too severely worked or scorched trees also present striking examples of the depletion of this tissue, resulting from conditions destructive to the health of the tree.

CHANGES IN THE INTERNAL STRUCTURE OF TREES FOLLOWING TURPENTINING

EFFECT OF TURPENTINING ON GUM-YIELDING TISSUES

In the new wood formed after a tree has been turpentined notable changes occur, especially in the amount and distribution of the resinous tissues in the region above and close to the sides of the face or wound. The structure of the wood formed during previous years

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is not altered, for each year's growth is practically complete at the end of the current growing season. Plate 2, *A* and *B*, illustrate the appearance respectively, at the same magnification, of a normal annual ring and a ring formed after the turpentining in a young slash pine. The resin passages are much more numerous in *B* than in *A* and a number of them in *B* are in the spring wood. The differences shown represent a fairly average result, as found at mid-streak between the shoulder and the peak (p. 67) of the streak in ordinary commercial turpentining. The actual number of resin passages may vary widely, for frequently there may be 3, 4, or even more times as many resin passages in the rings formed during turpentining as in those produced by the unturpentined trees. Again, if the tree is feeble the difference in number may not be pronounced. There is, however, a general tendency for an increase in resiniferous tissue production following wounding, which is often accompanied by a narrowing of the annual ring and a reduction in the amount of summer wood formed directly above the face.

There also appears to be an increase in the activity of the resin passages already present in the vicinity of the streak (p. 61) as the result of the wound of turpentining. This has led to the practice of using the advance, or healing, streak when installing a new operation (p. 47). The gum exuded from these resin passages already present in the round timber is alone responsible for filling the cups for the first and sometimes for the second time during the first year of turpentining. The gum exuding from these resin passages as they are exposed by freshening streaks is also a considerable factor in the yield for the first 2 or 3 years or even longer during the operation of a given face. The yield thus obtained is, however, greatly augmented in vigorous trees by the gum coming from the resin tissue in the new annual rings formed after turpentining has begun. Indeed, the yield from these outermost rings may, in some cases, be several times as great as the yield from the older wood when 2 or 3 new annual rings have been formed. In fast-growing trees a half inch of wood or the entire exposed surface of the streak may be composed of wound-induced tissues by the end of 3 to 4 years. On the other hand, the wood formed above the face during 8 years of continuous turpentining may not occupy one-fourth inch in some trees so that it is easy to understand why the relative yields produced by the old and new wood may vary greatly in amount.

An illustration of the distribution of resin passages above the face in a young longleaf pine is presented in plate 3. The decrease in the number of resin passages in relation to the increase in distance above the face is apparent from the three blocks cut at varying distances above the face. Many of the resin passages in the spring wood and in the summer wood near the butt of the tree are formed at the same time as those in the corresponding positions higher up; but more and shorter ones are also formed in the immediate vicinity of the face. Some of the resin passages formed, say in midseason, together with those intimately connected with them, may extend for a distance of more than 20 or 30 feet, but others are short. The short resin passages may be entirely cut away and wasted

by one season's heavy chipping. Plate 3 illustrates in block *B* the general increase in number of resin passages formed after turpentining has begun. The resin passages appear as black dots. They are particularly abundant in the three annual growth rings next the bark, a condition which is very apparent if these rings are compared with the inner rings which were formed before the tree was turpentined (pl. 3, *B*, *a*, compared with the other rings in *B*).

When block *B*, cut 3 inches above and to the left of the peak, is compared with block *C*, cut 12 inches above it, and with block *D*, cut 18 inches above *B*, the decrease in the number of these resin passages corresponding to the increase in height above the chipping is apparent. In definite numbers counted on the surface of 1 inch of wood measured along the circumference of the tree about midstreak, 108 vertical resin passages were counted in the growth ring just completed next the bark in block *B* (pl. 3, *B*, *a*). In block *C*, which was taken 12 inches higher in this same tree, only 54 resin passages were present in a similar area of the same annual ring directly above that measured in the *B* block. Eighteen inches above the *B* block and on a similar area only about 33 resin passages were present in the ring. The average number of resin passages per ring in similar areas from five rings formed before turpentining began was about 25. The number of resin passages prior to turpentining was practically the same at all three heights. Both the resin passages present in the outer rings of the round timber and those produced in the rings formed during turpentining contribute to the yield of gum.

EFFECT OF TURPENTINING ON THE OTHER WOODY TISSUES

With the methods used at present in commercial turpentining in the United States there is generally a distinct reduction in the width of the rings formed directly above the face after turpentining has begun, as is shown in plate 2, *A* and *B*. The amount and density of the summer wood is usually also reduced, although in very conservative working of trees with narrow annual rings there may be little or no reduction (*91*, *193*). The general narrowing of the annual ring may extend for 40 or 50 feet above the face in heavily worked trees. The narrowing of the rings in most cases does not extend around the circumference of the tree. Indeed the rings formed during turpentining are sometimes wider than before on the side of the tree opposite the face. Where the wood tissues grow in at the sides of the face in the process of covering the scar the rings are usually both wide and well stocked with resin passages. However, some reduction in total wood formation in heavily turpentined trees has been reported (*98*).

The resin content of the wood formed during turpentining does not seem to be appreciably altered except in the area above the face where it may be somewhat higher than normal because some of the gum may soak into the tissues. Such soaking, especially as a result of deep chipping, may also occur in the sapwood behind the chipped face, if this area becomes unduly dry as a result of deep chipping or of woods fires.

METHODS OF OBTAINING GUM [12]

The business of obtaining gum from living pine forests has been carried on in the Southern States to a large extent by men who did not own the trees or the land exploited, but who leased from the actual owners the right to chip the trees for gum for a specified number of years. Sometimes these lessees also owned timberlands themselves. Frequently, moreover, men who owned timberlands also chipped their own trees. In general, however, the practice of leasing a tract, obtaining what it would yield and moving on to new forests, has been prevalent (*364*, *511*).

It is only in comparatively recent years, when, with the passing of the virgin stands, the producing power of second-growth timber has begun to be realized, that definite plans for the owning and continuous operation of permanent holdings (p. 94) have assumed a significant place in the program of land utilization in the region (*10*, *104*, *106*, *116*.)[13]

The conducting of a naval stores operation involves numerous steps and the application of various methods. These together with the tools and equipment used are enumerated and discussed in the following pages (*111*).

SIGNIFICANT FACTORS AFFECTING THE SELECTION OF A STAND

The selection of a stand of timber for turpentining is influenced by many considerations, such as its position in relation to markets, still, and camp site, and transportation facilities. Ideal conditions seldom exist in forest stands at present, but certain qualifications may be set up covering some of the features considered most significant (*113*).

The fact that the requirements for ideal turpentine timber and for ideal pole or saw timber are not the same must be faced at the outset. The second-growth stands now coming into production will probably represent something of a compromise between the two types. On good sites at 50 years of age, longleaf pine trees should average about 70, and slash pine trees about 80 feet in height. The length of the crowns should be not less than one-fourth the total height of the trees and preferably for high gum production it should be, particularly in early life, one-half or even more of the length of the stem. The trees to be cupped should average over 9 inches in diameter at 4½ feet above the ground. The rate of growth, determined by sampling a representative number of trees with an increment borer, should show whether they offer a reasonable prospect of good yields. Sometimes the sapwood and the rings may be very narrow, as in badly suppressed trees, or the rings may show a recent narrowing indicating that the trees are suffering from a decadence even though the external appearance may indicate good yields. A stand of 50 or even fewer trees per acre may be considered good. In recent years operations have been conducted

[12] Prepared mainly from the results of tests and from field observations and notes obtained by Austin Cary, Branch of Public Relations; Eloise Gerry, Forest Products Laboratory; I. F. Eldredge and Lenthall Wyman, Southern Forest Experiment Station, Forest Service, with the cooperation of the naval stores industry.

[13] CARY, A. PROGRESS OF NAVAL STORES INDUSTRY. U.S. Dept. Agr., Forest Serv., Forest Serv. Bull. 10: 2–3. 1926. [Mimeographed.]

in stands with only 20 trees per acre. A fully stocked stand developed under careful management, however, may contain 100 to 250 trees per acre at its first working, depending on the management plan used (p. 98).

LEASING STANDS FOR NAVAL STORES PRODUCTION

A good lease is important to both timber owner and turpentine operator. Many persons who own timber know little about the actual operation of turpentining. It is to the advantage of both the timber owner and the turpentine operator to have a well-drawn lease outlining the terms of the contract or working agreement that exists between them.

Often owners of timber, eager to obtain an immediate large revenue from their land, have insisted that the operator leasing the turpentine rights shall hang as many cups as possible. This may result in a serious disadvantage to both parties. Small trees prematurely cupped have their growth unduly checked. Frequently they do not yield a profit so that the cost of their operation must be borne in part by the more productive trees. Such working of small trees not only damages the owner's timber but also reduces the operator's supply of available trees to insure sustained and profitable future workings. During recent years the working of small trees has been discouraged so that in many operations no tree under 9 inches at breast height (4½ feet above the ground) is now worked unless it can be found profitable to obtain the gum prior to the early removal of the trees for the purpose of improving the stand. A convenient caliper distributed free of charge by the Naval Stores Factors Association (*318*, *548*, *557*) to operators has done much to check the working of small trees. Any tree that will fit into the 9-inch opening of the caliper is classed as too small for regular turpentining (p. 79).

LENGTH OF LEASES

Leases cover the working of trees for a period of 2 to 6 years or even longer. The leasing for a long term with due provision for price adjustments makes it possible for the operator to work the timber to the best advantage if he desires and is capable of so doing.

COST OF LEASES

The lease prices paid per face vary considerably from time to time. Recently lease prices have ranged from about 10 cents a face to a maximum of 25 cents for 3-year periods. Partly worked or high faces and back cups usually cost slightly less. A marked increase in the cost of leases has occurred with the passing of the virgin forest. For instance. in 1896 a 4-year lease cost only half a cent per face (*536*), but with the gradual decrease in available timber, prices rose so that in 1931 a price of 7 to 12 cents a face [14] was common.

[14] Schedule of Forest Service lease prices, Choctawhatchee National Forest, 1931.

Instead of paying a flat lease price per thousand cups the operator sometimes works the timber on shares with the owner. In such cases the operator may pay the owner or lessee 15 to 30 percent of the gross sale value of the turpentine and rosin produced.

OTHER SPECIFICATIONS

A clear understanding should exist between the timber owner and the operator if the timber is leased, or between the owner and his woodsmen if he is working his own timber, as to whether the woods are to be burned over annually (raking and burning practice) or whether the woods are to be worked unburned (rough). The size and type of trees to be cupped, the number of faces per tree, the width of bark bars to be left between faces, the width of faces permitted, and the depth and height of chipping to be used, all of which will definitely limit the size of the face permitted on the trees, should be agreed upon.

A specimen lease is given in the following paragraphs and the advantages and importance of the different methods enumerated are also discussed under their respective heads in the subsequent pages.

A DESIRABLE FORM OF LEASE OR OPERATING CONTRACT

The following forms [15] incorporate procedures found of value to both timber owners and turpentine operators and may be used as an example of good practice (*576*, *577*). It can easily be modified to meet special requirements of the contracting parties.

NAVAL STORES LEASE

This naval stores lease, made and entered into this the ---- day of ----------, A.D. 19--, between -------------------- of ------------------- County, ----------, hereinafter called the owner, and ------------------ of ---------- County, -------------------- hereinafter called the producer.

Witnesseth, that the owner, for and in consideration of the rents and royalties hereinafter mentioned, does hereby grant, bargain, lease, let and convey unto the producer the exclusive right to work, for naval stores and turpentine purposes, by the cup system only, in accordance with the restrictions and provisions hereinafter enumerated, the longleaf and slash pine timber, hereinafter described, now standing and growing upon the lands of the owner, in ---------- County ----------, ----------, and more particularly described as follows, to wit:---

----

Excepting, however, from this lease, all trees, upon the above-described lands, as have been reserved and designated by the owner, and all trees as are unfit for turpentining, because of defects, abnormality or inaccessibility.

That the owner hereby fully warrants the title to said timber and will defend the same against the claims of all persons whomsoever.

That the owner warrants that there are no mortgages, liens, tax liens, or other encumbrances upon the above-described lands, except as follows, to wit:

That for and in consideration of the rights and privileges herein granted, the producer agrees to pay unto the owner the following sums at the times and in the manner following, to wit:

(Cross out the two methods of payment not used)

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[15] This form was prepared by C. H. Coulter of the Florida Forest Service, and Bureau of Chemistry and Soils, and Lenthall Wyman, Southern Forest Experiment Station, with the cooperation and advice of a number of leading timber owners, turpentine operators, factors, and lawyers. The form used by the Federal Government when leasing timber to be turpentined is given in U.S. Department of Agriculture Bulletin 1061 (*377*) *p. 33*.

FORM 1

The sum of ____ cents per face for the full term of this lease, the amount to be determined by actual count when cups are installed. Said payment to be made in the following manner, to wit:
$____ on or before the __ day of ____ 19__.
$____ on or before the 1st day of June 19__.
$____ on or before the 1st day of June 19__.

FORM 2

The following sums per face, payable on or before the ____ day of __________ each year during the term of this lease, the number of faces to be determined by actual count when the cups are installed, to wit:
____ cents per face for the first year.
____ cents per face for the second year.
____ cents per face for the third year.
____ cents per face for the fourth year and each year thereafter.

The above-enumerated sums per face to be effective during said years, provided the average unit price of turpentine and rosin does not exceed _____________________ dollars per unit; but should the unit price of turpentine and rosin exceed the aforesaid average unit price during any or all said years, then and in that event the producer shall pay to the owner an additional __________ cents per face for each ___________________ dollars advance in price over the above the aforesaid average unit price, such additional sum to be payable on the __ day of __________ the following year. It is hereby agreed that a unit of turpentine and rosin consists of 50 gallons of spirits of turpentine and 3⅓ round barrels of rosin of approximately 500 pounds gross weight each. It is further agreed that the price per unit shall be determined by taking the average daily strong and firm Savannah markets of all grades of rosin and turpentine for the 12-month period ending on the __ day of __________ of each year.

FORM 3

That the producer, at the time of sale, shall pay to the owner __________ percent of the net returns received from the sale of all products. Said net returns to be determined by deducting all freight, loading, handling, grading, inspection, storage, and commission charges from the gross returns for the sale of the products. Should the average net returns per unit per year exceed __________ dollars per unit, hereinafter called the basic price, then an additional ____________ percent of the net returns shall be paid unto the owner for each __________ dollars advance in price per unit over and above the basic price, said additional amount to be due and payable on the __ day of __________ the following year after sale.

That the unit price per year shall be determined by taking the average net returns from all turpentine and rosin sold hereunder during that year, expressed in terms of unit value, that is, a unit of turpentine and rosin to consist of 50 gallons of turpentine and 3⅓ round barrels of rosin of approximately 500 pounds gross weight each.

All products shall be sold and/or contracted for to the best advantage of the owner and the producer, but should they fail to agree as to the advisibility of selling and/or contracting such products either party may at his option, take over his proportionate share of such products.

Tbe producer shall insure and be held liable to the owner for the owner's interest in all products in the process of distillation or held or stored at the still or in the yard, excepting such products as have been taken over by the owner.

All rosin and spirits of turpentine shall be inspected by a Federal or authorized State inspector before sale.

The producer shall make arrangements with his factor or purchaser to furnish the owner with a full statement, at the time of sale, showing in detail the amount of products sold, the amount received from the sale thereof and the items of expense deducted from the gross returns.

In order to obtain the best yield and grades and to eliminate waste the producer agrees as far as practical to:

Cup and streak all trees on or before the 1st day of February 19____; use rustless or rust-free cups and tins; use chip paddles which will cover cups and tins; place at least 32 streaks per year on all faces at 1-week or longer intervals; dip all gum at least every four streaks; raise cups at the end of each of the first four working seasons; distill the crude according to the methods of the United States Bureau of Chemistry and Soils as contained in Directions for Running a Turpentine Still, dated April 1, 1927, How to Charge and How to Discharge a Turpentine Still, dated March 5, 1924, and April 1924, respectively; insure the still from fire; cover the separator barrel and spirit tub; glue the spirit barrels by method contained in Bureau of Chemistry and Soils leaflet, Gluing Turpentine Barrels, dated July 15, 1931, or ship the spirits of turpentine in tank cars or drums in such a way to eliminate waste and discoloration; and strain rosin properly.

That the timber, embraced by this lease, shall be worked in accordance with the following restrictions and provisions, to wit:

1. This naval stores lease shall be for the full term of ________ working seasons, beginning as soon as this agreement is executed and delivered, and ending at midnight on the 31st day of December 19__.

2. All cups shall be installed not later than the 31st day of March next after the date hereof.

3. All round trees 9 inches in diameter and above shall be cupped with one face, provided, however, that with the written consent of the owner, trees measuring 15 inches or more in diameter may be cupped with two faces. No trees measuring less than 9 inches in diameter may be worked. All diameter measurements shall be taken 4½ feet above the ground.

4. One cup shall be installed on all trees previously worked that measure 12 inches or more in diameter 4½ feet above the ground, provided that no trees previously worked with more than one face or that measure less than 12 inches in diameter, as aforesaid, may be worked.

5. When two faces are placed upon any tree, they shall be located so that the width of one of the bark bars is not greater than 8 inches.

6. Bark bars not less than 4 inches wide shall be left between faces.

7. The faces shall be chipped for the first year not to exceed 16 inches in height from the shoulder of the first streak to the shoulder of the last streak of the season. The faces chipped or pulled yearly thereafter shall not exceed 14 inches in height for each season.

8. Measured in the deepest place, the depth of the streak shall not exceed five-eighths of an inch in the wood of slash pine or three-fourths of an inch in the wood of longleaf pine.

9. The width of the face shall not exceed one-third of the circumference of the tree, and in no case shall the width of the face exceed 12 inches, measured from shoulder to shoulder.

10. No wood shall be exposed below the gutters or aprons at the time the cups are installed; however, it is permissible to chop into burls and swellings to properly set the cups. All cups shall be installed as close to the ground as practicable and the first streak shall be cut as close to the gutters or aprons as possible.

11. Incisions in the wood for installing tins or raising in jump peaks shall not exceed one-half of an inch in radial depth. No incision or streak in the face for the purpose of raising tins shall exceed one-fourth of an inch in radial depth. Whenever tins or cups are raised, removed, or abandoned, all tins, tacks, and nails above a stump height of 14 inches from the ground, shall forthwith be pulled and removed, but not chopped out, by the producer.

12. Should the producer cup or fail to cup any tree or trees in violation of the above sections 3 and 4, he shall pay unto the owner, as and for full liquidated damages caused by said violation __________ cents per face cupped or that should have been cupped, provided however he shall have been notified in writing by the owner, within 60 days from and after the date of the said violation or from and after the 31st day of March 19—, whichever is the later date. That upon being notified as aforesaid the producer shall forthwith remove all cups installed in violation of sections 3 and 4 hereof, and his failure to so remove said cups shall constitute a breach of this contract, and the owner shall have the right to remove said cups at the expense of the producer.

13. Should the producer violate any of the restrictions and provisions herein contained, the owner shall notify him in writing, within 60 days after such violation has occurred, and if said violation is not ceased and any defective work corrected within 20 days from and after receipt of such notice, the producer shall pay to the owner, as and for liquidated damages, as follows:

(*a*) For all faces that exceed the heights specified in section 7 of this contract __________ of a cent for each inch in excess of the specified heights.

(*b*) For trees split or wind-thrown during the life of this agreement in violation of the above section 11 __________ dollars per thousand feet board measure full scale computed by the Doyle rule.

(*c*) For violation of all restrictions and provisions, other than those mentioned in sections 11, 12, 13*a* and 13*b*, hereof, __________ cents for each face worked in violation of these restrictions and provisions.

14. Should the producer fail or refuse to pay unto the owner the liquidated damages herein provided for, within 10 days from and after the same becomes due and payable, the owner shall have a lien upon the equipment of the producer used upon the lands above described, therefor, and may at his option, prohibit further work, under this lease, until such damages are paid in full.

That it is hereby further agreed by and between the parties hereto, that:

(*a*) The owner reserves unto himself the right to list any or all of the lands embraced in this lease with the State board of forestry, for forest-fire control. In case the said lands or any part thereof be so listed, the producer hereby consents to such listing and agrees to cooperate with the owner and the said board in said control; to plow, rake, and burn such fire lines as may be designated by the said board or the agents for proper fire control; to aid and assist the said board in preventing and suppressing forest fires on said lands; to require his servants, agents, employees, and all other parties under his control to cooperate in said forest-fire control, and to aid and assist in preventing and suppressing fires.

(*b*) That in case the owner lists the lands with the State board of forestry as aforesaid, and thereafter fails to carry out the terms of said protection agreement, then the producer may carry out the terms of said agreement, in behalf of the owner, and thereafter deduct the amount of the cost and expenses of so carrying out said agreement from any and all sums then due or to become due from himself to the said owner, under the terms of this lease, and should there be no sums due or to become due as aforesaid, then said amount of costs and expenses shall be a lien upon the lands embraced in said protective agreement.

(*c*) That the producer, his heirs and assigns, shall have the free and unrestricted right to enter upon, occupy, use, and enjoy said lands for the purpose herein granted during the continuance of this lease. It is further agreed that the producer shall have a period of 60 days from and after the expiration of this lease, within which to remove and take away, or otherwise dispose of, all cups, gutter irons, and other equipment belonging to him, provided he has carried out the terms of this agreement.

(*d*) That the producer shall be allowed to use dead and down timber from the aforesaid lands as fuel wood for his still and for firewood for his hands and laborers but not for removal or sale.

(*e*) That the producer shall have such free and unrestricted right of ingress, egress, and regress, upon the lands of the owner, as may be necessary for the purpose of working the timber, hereinabove described, for turpentine and naval stores purposes.

(*f*) That the owner shall have access to the lands above described, for any and all purposes not inconsistent with the terms and provisions of this lease; provided, however, that such use by the owner does not interfere with the operations of the producer. In the event of any such interference, the owner shall be liable to the producer for all injury and damage to his cups, tins, cupped trees, and products, caused by the owner's operations on said lands.

(*g*) Should the timber embraced by the terms of this lease be damaged by fire, insects, drought, act of God, or vis major so that, in the judgment of either party, further work would be impractical, impossible, or injurious to the timber, the parties hereto shall mutually agree as to what modification or suspension of work is necessary for the proper protection of the timber and the interests of the parties hereto; provided, however, that if said parties are unable to effect mutual agreement then such question shall be submitted to a committee of three arbitrators, one to be chosen by the owner, one by the producer, and the third by

the two so chosen, and the decision of said board of arbitrators shall be binding and final upon the parties hereto as to all questions arbitrated.

(*h*) That the owner shall pay the taxes upon the lands embraced in this lease before the same become delinquent and should the owner allow the taxes to become delinquent then, and in that event, the producer, in order to protect himself from having his operations stopped, on account of the nonpayment of taxes, shall have the right to pay such taxes and to deduct the amount of such payments from any payments due or to become due from said producer to the owner under the terms of this agreement, and in case there be no payments due from the producer to the owner aforesaid, the producer is hereby given a lien upon the lands of the owner to the extent of the taxes so paid.

(*i*) Neither party hereto shall be held liable, if prevented from the performance of his covenants and obligations hereunder by an act of God or major contingencies beyond his or their control.

(*j*) The terms "owner" and "producer" when used herein shall be taken as extending to and embracing the heirs, personal representatives, successors, and assigns of the parties hereto.

(*k*) The rights and privileges, under the terms of this lease, accruing to the parties hereto shall be assignable and transferable and when assigned or transferred the right and obligations hereunder shall devolve upon the assignee or transferee.

If any of the sums, herein referred to as compensation for this lease, be not promptly and fully paid within ---------- days next after they become, severally, due and payable, the aggregate sum of unpaid compensation for this lease shall, at the option of the owner, become due and payable forthwith, and if not fully paid within 10 days, after notice by the owner that he has elected to exercise his aforesaid option, this lease shall become terminated in toto and the owner shall have the right of re-entry.

In witness whereof the parties hereto have hereunto set their hands and seals the day and year first above written.

-------------------- [SEAL]
-------------------- [SEAL]

Signed, sealed, and delivered in the presence of:

ACKNOWLEDGMENT FOR PERSONS OTHER THAN MARRIED WOMEN

STATE OF ----------
COUNTY OF----------

On this day, before me, a notary public, personally appeared ---------- ----------, to me well known and known to be one of the persons who executed the above and foregoing turpentine lease, who acknowledged before me that he executed the same freely and voluntarily for the uses and purposes therein expressed.

Witness my hand and official seal this the -- day of ----------, 19--.

--------------------,
Notary Public.

ACKNOWLEDGMENT FOR HUSBAND AND WIFE

STATE OF ----------
COUNTY OF ----------

On this day, before me, a notary public, personally appeared ------------ ---------- and --------------------, his wife, to me well known and known to be the persons described in and who executed the above and foregoing turpentine lease who acknowledged before me that they executed the said instrument freely and voluntarily for the uses and purposes therein expressed, and,

The said --------------------, wife of the said --------------------, upon an examination taken before and by me, separate and apart from her said husband, further acknowledged that she executed the said turpentine lease freely and voluntarily and without any compulsion, constraint, apprehension, or fear of or from her said husband.

Witness my hand and official seal this the -- day of ----------, 19--.

--------------------,
Notary Public.

ACKNOWLEDGMENT BY CORPORATION

STATE OF ----------
COUNTY OF ----------

On this day, before me, a notary public, personally appeared ---------- ---------- and --------------------, to me well known and known to be the persons who executed the above and foregoing turpentine lease as president and secretary, respectively, of --------------------, a corporation, who acknowledged before me that they are the president and secretary, respectively, of the aforesaid corporation; that they executed the said turpentine lease, in behalf of the said corporation, freely and voluntarily for the uses and purposes therein expressed; that they caused the common seal of the said corporation to be affixed to the said instrument; that the seal affixed to the said instrument is the common and corporate seal of the said corporation.

Witness my hand and official seal this the -- day of ----------, 19--.

--------------------,
Notary Public.

INSTALLATION OF A CROP

NUMBER OF TREES IN A CROP

Before the cups are hung, the woods to be worked are laid out in operating crops, each of which contain the number of cups that one chipper can chip in 1 week. The number of cups in an operating crop will vary from 6,000 to 8,000, depending on the density of the stand and the ease of walking from tree to tree. The crop is again divided into drifts of about 2,000 cups for convenience in chipping and supervision. Statistically a standard crop is 10,000 faces, this number being a relic of the old days when the dense virgin timber stands of the Carolinas allowed faster working.

More time is usually occupied by the chipper in walking from tree to tree than in actually cutting the streaks. Even when there are as many as 230 trees per acre, 30 to 40 percent of the chipper's time is spent in walking. In poorly stocked stands, such as constitute a large proportion of the present woodlands, this time is much greater.

When a new crop of timber is to be cupped, it is customary to run the crop and drift lines to include the proper number of trees and to mark the boundaries with white paint applied to the bark of the trees.

A RIDE

Six to eleven crops may constitute a ride, that is, the area supervised by the woods rider (fig. 13) who is responsible for seeing that all trees are regularly chipped and dipped according to agreement.

OPERATING SEASON

The installation of new cups is carried on during the winter, chiefly from December to February. Regular chipping usually begins in March and continues until November (p. 65).

ADVANCE MARKING

Distinct advantage can be gained by sending an experienced man through the woods in advance of the actual installation of the cups, not only to mark the trees to be cupped but also to locate and mark with a paint spot the exact position of the face (fig. 14). Such a

man should have the judgment to eliminate unprofitable trees, prevent overcupping, and locate the faces properly with reference to later working as well as to avoiding defects, such as scars, knots, or

FIGURE 13.—A stand of mature timber being turpentined immediately before felling. In the foreground, the woods rider who is responsible for having the operations in the woods properly performed.

weak points due to feeble crown development on one side or to unthrifty branches. This selection of face position saves the time of the cupping crew and prevents many mistakes which might other-

wise occur during cupping, when many other matters require attention simultaneously. It may some day become the custom to scribe the boundaries of faces on the bark and even to remove the outermost rough bark in advance of the chipping.

PROCEDURE FOR HANGING CUPS

For the purpose of collecting the gum, cups or containers are attached to the trees. The hanging or placing of these cups and the gutters or aprons that accompany them is done during the winter.

FIGURE 14.—Advance marking by a competent woodsman of trees to be chipped insures careful selection of trees and proper location of faces (white paint spot indicates the side of the tree on which the face is to be placed).

CUPPING CREWS

Several men, each with specific tasks and tools (p. 47), constitute the cupping crew, the size of which may vary in different camps. Every crew, however, includes a supervisor who tallies the number of trees cupped, directs the placing of the cups and tins, and keeps the crew moving as a unit. A broadax cupping crew is composed of cup and tin (p. 58) distributors, axmen, maulers, chippers, and cup hangers. Cups and tins are first placed at each tree to be faced. The axman slabs off the bark, prepares the place for seating the cup and holds the ax in place while the mauler strikes it to form the cut

for inserting the tins (fig. 15). As the ax is withdrawn from the cut, the mauler slips the tin into the incision (fig. 16). The chipper then cuts the advance streak, drives in pegs or nails and hangs the cup. When hogals or tree facers (p. 49), and gutter chisels are used

FIGURE 15.—Making an incision not to exceed one-half inch in depth in which an apron is placed.

the hogal man slabs the bark off and cuts the advance streak. The man with the gutter chisel holds his chisel in place with one hand and uses his other hand to strike it with a mallet (fig. 17). The tin setter slips the tins in place as the chisel is pulled out. Usually

another man follows to hang the cups. A cupping crew generally hangs from 650 to 1,000 cups a day.

ADVANCE STREAK

It is the general custom to cut a streak just above the apron on the butts of trees that are to be turpentined for the first time, well in advance of the regular chipping. This streak is known as the advance or "healing" streak. It is widely held that this procedure gives higher yields than if the first streak were cut in March or April when the regular weekly chipping begins.

Some operators cut the advance streak just before the cupping crew inserts the aprons. This practice makes it possible to place the streak closer to the apron or gutter than is readily accomplished after these are in place (fig. 18).

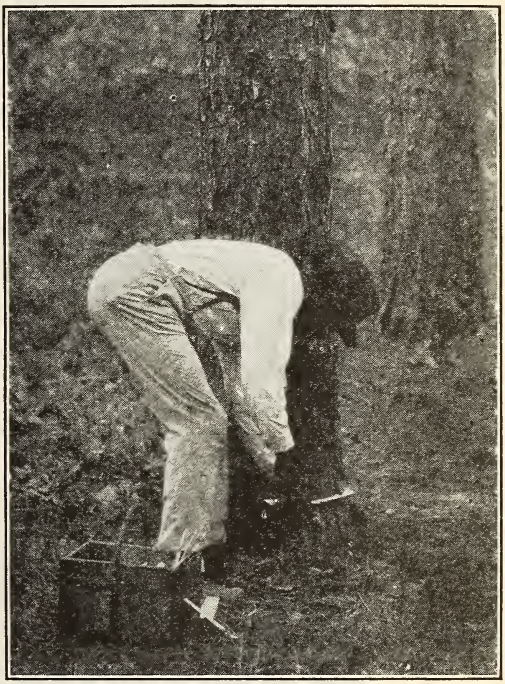

Figure 16.—Inserting the apron in a broadax incision in the butt of the tree. Though the rough bark is removed, the wood has not been exposed.

TOOLS

Little change in the general type of tools used in the turpentine industry has occurred in recent years, although fire-fighting equipment and implements that are useful in the construction of firebreaks have been added to the equipment of many turpentine camps. The types of tools in most general use at present (*143*, *144*) are discussed in the following paragraphs.

CALIPER

A measuring tool for gaging the diameter of a tree is called a caliper. A forester's caliper has a movable arm. A simple caliper with a fixed opening 9 inches wide has been designed and issued by the Naval Stores Factors Association. It serves, if properly used, to eliminate trees less than 9 inches in diameter; that is, any tree so small that it could be encircled by the caliper opening is too small for regular working. Calipers can readily be made with openings of any size desired.

BROADAX

Broadaxes with a double or single bevel and a straight edge 8 to 13 inches in length (fig. 19, *a*) are favored for making apron incisions rather than the concave axes formerly used, because there is less danger of cutting too deeply into the tree. The broadax may also be used for removing the outer bark and preparing a place to seat the cup.

FIGURE 17.—Demonstrating method of making an incision with a gutter chisel for raising cups. Actually the gutter or apron would not be set in an incision placed so far below the top of the face.

MAUL

A heavy wooden maul (fig. 19, *c*), weighing about 8 pounds, is generally used to drive the broadax with which incisions are made in the trees for setting aprons. A lighter maul or mallet which can be handled with one hand is more commonly used for driving in the gutter chisel.

GUTTER CHISEL

Broad chisels, sometimes called "Pringle axes", having blades 6 to 12 inches across and with the edge either straight or curved (figs. 17 and 19, *b*) are often used instead of axes for making apron or gutter incisions. They are especially useful for the insertion of two-piece aprons. One man usually holds the chisel and drives it with a mallet.

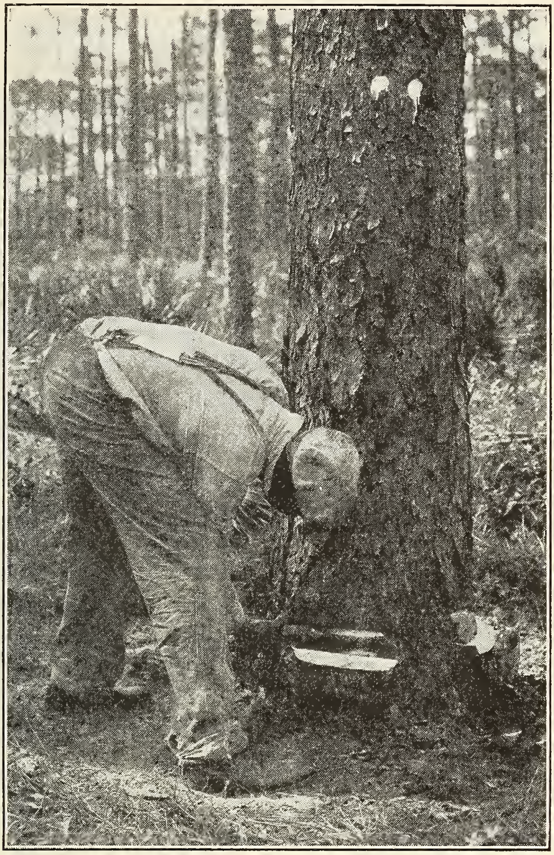

FIGURE 18.—Cutting the advance streak. This can be done with the apron in place, but it is more easily accomplished before the apron is set.

APRON SETTER

A holder is used with saw-toothed aprons to avoid crumpling their edges when they are driven into the incisions.

TREE FACER

The tree facer, or hogal (fig. 19, *d*), may be used instead of a broadax for smoothing off the rough bark where the cup and apron are to be set and often for chipping the advance streak. The hogal is most commonly used in operations where the chisel has replaced

the broadax. The hogal, which is used with a pulling motion, is easier to control than a broadax and its use generally decreases accidental damage to the tree from unnecessary butt scarring. A chipping tool similar in general shape has been developed (fig. 20) and used in the Southern Forest Experiment Station tests (*273*).

In foreign countries it is customary to remove a considerable amount of the rough outer bark over the entire area to be occupied by the face of the current year (p. 159). This practice facilitates accurate chipping and reduces the amount of trash shed at each chipping. It is especially desirable when the bark is very thick, as in vigorous young southern pines, or where the bark has been charred.

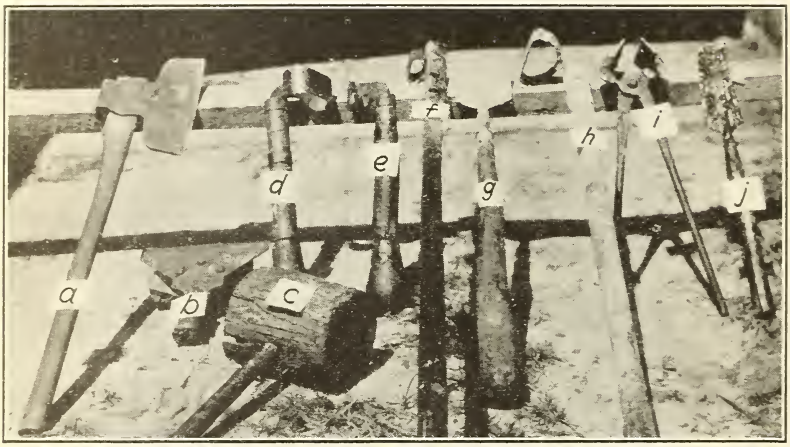

FIGURE 19.—Tools: *a*, Double bevel, straight-edge broadax used for removing the bark in preparing a place to seat the cup and also for making the incision to hold the apron; *b*, gutter chisel, or Pringle ax, having the same use as the broadax (*a*) for making apron incisions; *c*, maul used for driving the broadax into the tree to cut incisions for aprons; *d*, hogal used for removing the rough bark at the butt of the tree and frequently for cutting the first streak; *e*, hack for cutting streaks on low faces; *f*, puller for cutting streaks on high faces; *g*, shove-down scraper for removing scrape from low faces; *h*, double-edged pull-down and shove-down scraper for use on high or low faces; *i*, apron or gutter puller for use in pulling aprons preparatory to resetting; *j*, dip iron for removing gum from the cups.

When the large virgin pines in the Western States were turpentined the removal of the outer bark was generally essential, for otherwise it would have been impossible to chip with an ordinary hack.

HACK

The hack, or chipping tool (fig. 19, *e*), is the principal tool used in gum production. It has been customary, during the period of the first 3 to 5 years of an operation, to use a hack for chipping or freshening the face on the tree so that gum will exude. Every working season each face is chipped once, or sometimes at midseason twice, each week so that a hack is used on the average 32 times on each face each year. It has been estimated that on the average five hacks are used per 10,000 faces per year. The average hack will chip one crop about six times (60,000 streaks), which is equivalent to cutting through more than 10 miles of wood; some hacks are known to have passed through 25 miles of wood (*144*). This gives some indication of the type of material required for the hack blade, the shape and

size of which varies somewhat. The hack is fastened to a handle 10 to 30 inches in length at the end of which a 4- to 7-pound weight is attached. The average total weight of the tool is about 7 pounds. The weight serves to give added force to the cutting stroke of the chipper.

The sizes of hacks (fig. 21) range from 00, which has a very narrow opening or "bill" about five-eighths of an inch, to no. 3, with a very wide opening of about 1¼ inches. A definite tendency toward the adoption of smaller hacks has developed during recent years so that the no. 3 hacks are now obsolete. The chief demand for hacks is now for no. 1's or smaller sizes. Considerable activity

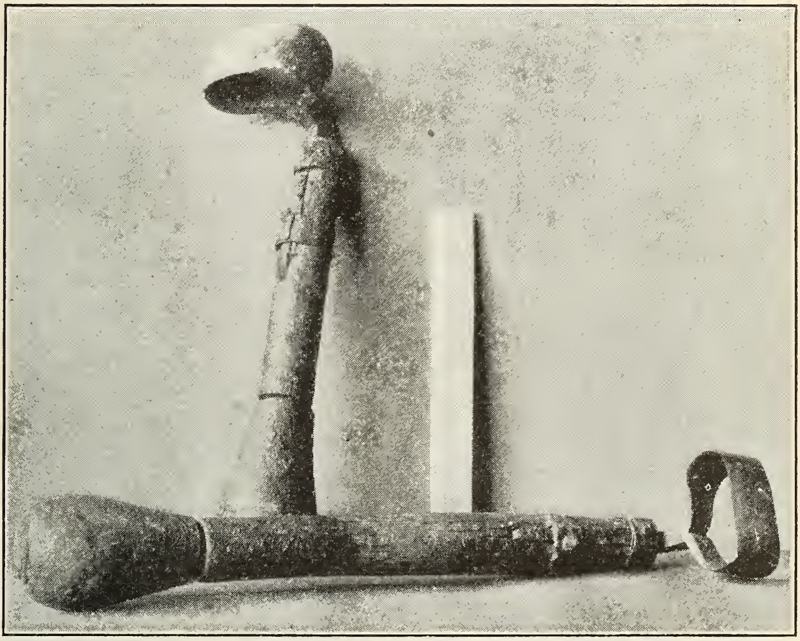

FIGURE 20.—Two views of chipping tool used in cutting French faces by the Southern Forest Experiment Station.

in developing gaged hacks and cutting tools with modified shapes has occurred in recent years but has not yet markedly changed the tools used by operators. Types of hacks with blades that can be removed from the shank so that sharp blades may be substituted when a blade becomes dull during chipping have been introduced. By using such a tool the chipper does not have to take time to sharpen a dulled tool before he continues chipping. The dulled tools, moreover, can all be turned in at a central point and conditioned by a man with proper equipment specially assigned to this task.

All the most successful operators place great emphasis on the importance of chipping with sharp tools. Hack stones and cutters for keeping the cutting edges of the hacks keen are carried by all chippers.

A square-cornered hack designed to eliminate the ridges now produced by most of the chipping carried on in the United States has been used on a small scale with success in the Western States.

CUP PROTECTOR

A cup protector, generally known as a chip paddle, is used to cover the face, apron, and cup when the tree is being chipped. The

FIGURE 21.—Hacks used for chipping pines. The sizes (left to right) are 00, 0, 1, 1½, 2, and 3, respectively. No. 3 has been abandoned to reduce the danger of damage to the timber.

form shown[16] is made of a single piece of wire looped in the middle to form a handle and with the two ends serving as extended arms about 20 inches apart. Over these arms is fastened a piece of bur-

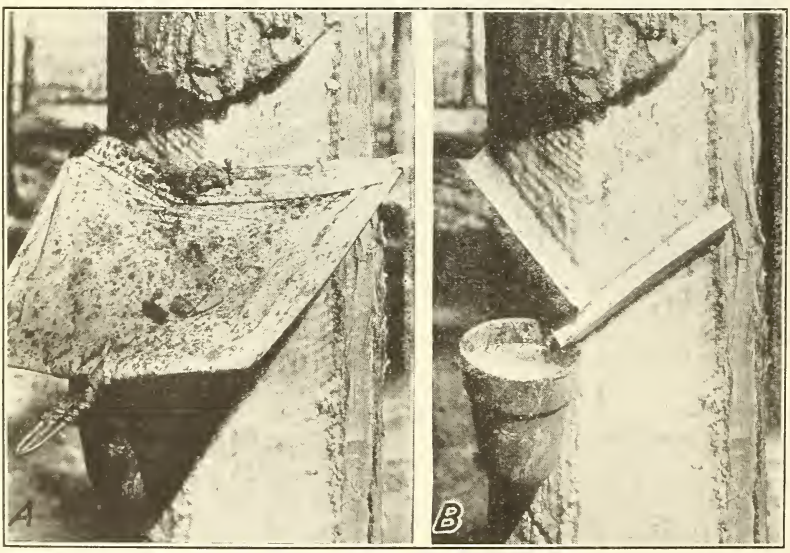

FIGURE 22.—Cup and gutter protector used to keep trash out of the gum while the tree is being chipped: *A*, In place; *B*, cup and gutter after removal of the protector.

lap, the loose end of which is placed against the tree so that it gives complete protection to the cup and apron beneath. This device has been slightly modified by the Southern Forest Experiment Station by substituting canvas for burlap and adding other features to

[16] Developed by W. H. Gregory, Lake City, Fla. (*256*).

increase its durability and usefulness (*86*). By the conscientious use of this cover (fig. 22), trash and chips are to a large extent kept out of the gum in the cups and consequently are not included in the dip where they cause waste and loss at every step and may if included in the still charges cause darkening and degrade of the rosin.

PULLER

When the face is so high that it is difficult to use a hack, a puller, which is a chipping tool mounted on a handle usually 3 to 5 feet in length (fig. 19, *f*), is used for freshening the streak. With this tool the weight of the chipper's body plays a part in the cutting stroke that removes the wood when the streak is made.

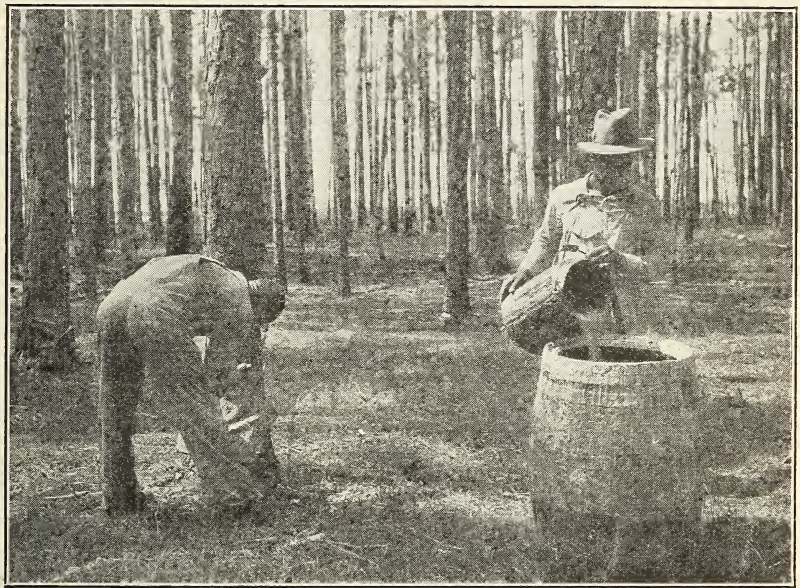

FIGURE 23.—Emptying the gum or dip into the dip barrel. Note chipper at left using canvas cover to shield cup and apron from chips and trash.

DIP IRON

A steel-blade dip iron for removing the gum from the cups is shown in figure 19, *j*. Home-made wooden paddles also serve for this purpose and have the advantage that they do not bring iron which can cause discoloration of the rosin, in contact with the gum. Wooden paddles should be used when the more easily marred aluminum cups and aprons are employed. The shape of the dip iron may differ slightly depending on the type of cup which is to be dipped.

DIP BUCKETS

Wooden or galvanized-iron dip buckets, ranging in size from 3 to 8 gallons, with an average capacity of about 6 gallons, are used in collecting the gum from the cups and transferring it to dip barrels set out in the woods to receive it (fig. 23). Nail kegs of about 5-gallon capacity are frequently used for dip buckets.

SCRAPE IRON

A scrape iron is used for removing the hardened gum, or scrape, that adheres to the face of the turpentined tree. This tool has a blade with a moderately sharp edge so that it often removes the projecting ridges of wood left between the streaks. Three types of scrape irons are used, namely, shove-down scrapers for low faces (fig. 19, *g*, and 24, *A*), double-edged, shove-down, pull-down scrapers for high faces (fig. 19, *h*, and 24, *B*), and scrape irons attached to buckets (fig. 25) used with a push-up motion for high faces. The demand for shove-down scrapers is decreasing because it is now customary not to allow the scrape to collect on low faces but to remove it each time the gum is dipped out of the cup. Pull-down scrapers are made with either a single or a double edge; the double-edged tool can be used for both pulling and pushing.

SCRAPE BOX

Wooden boxes, with legs and a handle attached, are used for scrape collection. They are usually made from any convenient box available. Some scrape boxes are equipped with wheels (fig. 24, *A*) and lined with oiled burlap to facilitate emptying.

APRON OR GUTTER PULLER

The apron or gutter puller, illustrated in figure 19, *i*, is used for pulling aprons and gutters preparatory to raising and resetting the cups.

EQUIPMENT

CUPS

The adoption of cups or movable containers to catch the gum that exudes from the chipped pine trees was one of the most significant improvements in operation thus far made by the gum gatherers of the United States. The early exploiters of pines in France were accustomed to collect the gum in holes dug in the ground at the base of the tree. In the United States, however, "boxes", cut in the wood at the base of the face, were universally employed until it was conclusively shown that the cup system, which in the meantime had been adopted in France, resulted in larger yields, better quality gum, and reduced damage and waste of timber (*282*, *283*, *286*, *288*, *384*).

SHAPE OF CUPS

Cups are chiefly of three shapes (fig. 26): The flowerpot shape, the oblong, and the conical. Some modifications, such as a covered glass cup (fig. 26, *D*) to be used to collect gum exuded through auger holes bored in the tree and other more or less covered cups or various shaped cups, have been tried from time to time but have thus far failed to achieve any wide application commercially in the United States. The auger-hole method as used in the United States produced excellent clean gum, but the yield did not continue for very long on the average. Freshening the borings was difficult, costly, and of limited application. In 1931 an effort was made in France to revive the

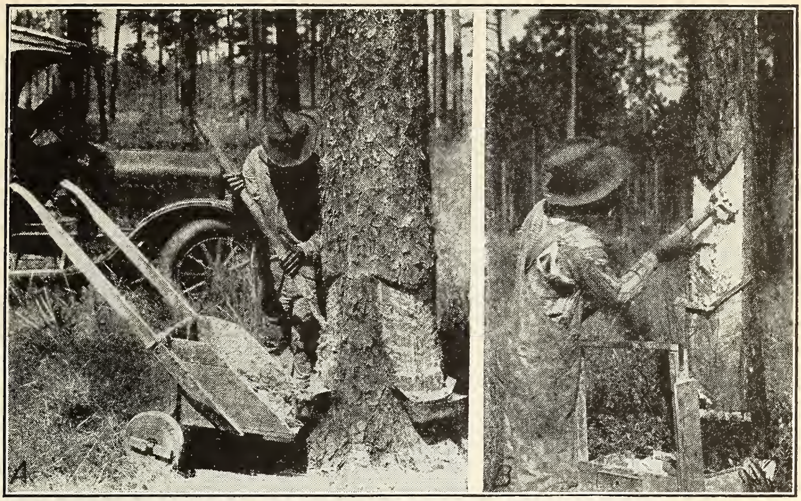

FIGURE 24.—*A,* Scraping with a shove-down scrape iron into a scrape box; *B,* pull-down scrape iron in use.

FIGURE 25.—Scrape iron attached to a galvanized bucket which catches the scrape and prevents it from being lost or degraded by falling on the ground.

Courtesy of the Florida Forest Service.

boring method. A geared, rotary, high-speed cutting tool which removed very thin shavings was developed (*411, 412, 468*). With this a shallow conical hole was cut in the tree. The final dimensions of the hole were 4 inches in diameter and 0.4 inch in depth. The cut was protected by a cover with a hinged glass door through which light could reach the cut surface of the tree. A glass bottle was then attached in such manner as to exclude the free circulation of air and the entrance of rain water and trash from the gum as it collected. It was reported that an "anticoagulant" was used in the bottle to keep the gum liquid. Full data on yields of gum were not given.

MATERIAL FOR CUPS

The chief materials employed in cupmaking are clay, galvanized iron, aluminum, zinc, and rarely glass. The requirements for cup material include low cost, ease of handling with particular reference to weight and breakage, composition that will not deteriorate readily or degrade or discolor the gum, together with general durability with respect to dipping, cleaning with hot soda or lye solutions, exposure to weather and to fire, as well as possessing salvage value. Table 6 lists representative types of cups and some of their relative advantages and disadvantages.

TABLE 6.—*A comparison of the characteristics of representative turpentine cups*

Material	Shape	Capacity	Advantages	Disadvantages
		Quarts		
Clay	Flowerpot	1, 1½	Do not discolor the gum hence permitting production of high-grade rosin. Possible savings of turpentine due to depth of cup and low heat conductivity of material. Easy to dip.	Heavy, about 2½ pounds each, may break in handling and as a result of freezing if not particularly cared for. Tend to cause virgin faces to be higher above the ground than with oblong cups.
Galvanized iron	Oblong	1, 1½, 2	Fairly light, about ½ or ¾ pound each, rigid, compact, and durable in handling and use. Easy to dip. Not damaged by cold. Can be set close to ground.	Deteriorate rapidly, discoloring gum and rosin. Care required to keep level on small trees. Relatively large surface of gum exposed to the air
	Oblong coated with bakelite.	1, 1½, 2	Last 4 seasons [1]	Costly, seldom used.
	Conical	1, 1½	Light, about like oblong cups, easily handled, not damaged by cold.	Deteriorate and rust; somewhat harder to dip than other cups. Tend to tip and spill gum unless special care is used.
	Flowerpot (rare)	1, 1½	Light, easily handled	Deteriorate and rust. Bottom may burst by freezing.
Aluminum	Oblong	1, 1½	Very light (lighter than galvanized iron), do not deteriorate chemically, so keep gum clean, not damaged by cold. Possess salvage value.	Fragile, soft, bend, and puncture. May be difficult to keep level. Costly.
Zinc	do	1, 1½	Durable, compact, keep gum clean, not damaged by cold.	Difficult to keep level. Costly.
Glass	Closed cylinder	½, 1	Clean gum, reduced evaporation.	Not practical at present. Yields and operation unsatisfactory.

[1] Shingler, G. P. (*485*).

FIGURE 26.—Containers used for holding gum: A, Flowerpot-shaped clay cup used with gutters; in this installation the first streak is usually about 15 inches above the ground. *B*, Oblong galvanized-iron or aluminum cup; usually the first streak is about 7 inches above the ground. *C*, Conical cup used with gutters and ordinarily set higher above-ground than *B*. The cup shown has already been raised once. Rule at right is marked in black-and-white inch squares. *D*, Closed glass cup, not now in commercial use.

ATTACHMENT OF CUPS

The flowerpot-shaped and the conical cups are hung on nails. Sometimes conical cups are supported by two nails. Wooden pegs as well as nails are used to support the oblong cups. When nails are used great care must be taken to insure their removal when they have served their purpose, for otherwise they may cause serious damage at the sawmill if the butt logs are later cut into lumber. The cups are also held in place to a greater or less extent by the metal aprons or gutters, which extend over the edge of the cup, serving as a bridge to conduct the gum from the face into the cup.

TINS

The term "tin" is applied to both the aprons and the gutters which are used to aid in conducting the gum from the face into the cups. The aprons and gutters used in the United States are not, however, made of tin, but of other materials, including galvanized iron, aluminum, and zinc.

APRONS

The material used for aprons is generally galvanized iron, but occasionally zinc or aluminum is also used (table 7). The aprons vary widely in shape and size (pl. 4). They may be in 1 or 2 pieces and may have a plain or saw-tooth edge for insertion into the tree or else may be tacked or nailed or even held in place by small wooden pegs.[17] It is important that nails and tacks be coated to present a rust-resistant surface, for otherwise they will play a part in the discoloration of the gum. There is much individual variation in the method of attaching aprons and in the shape as well as the material preferred The chief object is to secure a firm attachment of the cup and to catch the gum excuded so that it will not be wasted, as well as to facilitate its passage into the cup. With saw-toothed aprons it is possible to make a lighter incision than with ordinary aprons and yet obtain a firm seat.

TABLE 7.—*Comparison of materials for aprons and gutters*

Material and use	Advantages	Disadvantages
Galvanized iron:		
Aprons	Strong, hold firmly when nailed, cheap. Saw-toothed form, permits slight incision.	Deteriorate rapidly and cause discoloration of the rosin (efficient life 1 to 2 years without serious rusting).
Gutters	Strong	Stiff when bending required. (Same tendencies as above.)
Aluminum:		
Aprons	Do not rust	High initial cost. Too soft to drive.
Gutters	do	High initial cost. May tear around nails. Do not hold shape. Little used.
Zinc:		
Aprons	Give long service without damage to rosin grades. Stiff enough to drive.	High initial cost.

[17] A method for using wooden pegs similar to shoe pegs for attaching perforated zinc or galvanized-iron aprons to eliminate making an incision for apron setting has been worked out and applied but found costly under present conditions by R. R. Long, Conecuh Naval Stores Co., Atmore, Ala.

GUTTERS

The bent metal strips known as gutters (pl. 4, *C* and *D*) serve the same purpose as aprons, but are better adapted for use with such types of cups as the flowerpot and conical and for use on small trees (pl. 4, *B*). Gutters are either inserted in cuts made for the purpose or are attached to the trees with tacks, nails, or rarely wooden pegs.

NAILS OR PEGS

The cups, especially oblong ones, are supported by nails or pegs which hold them under and against the aprons. Where timber is to be sawed into lumber the large nails used to support the cups are highly undesirable since they may not all be removed or may break off inside the tree. Various types of wooden pegs have been adopted therefore in place of nails. In some cases hardwood pegs resembling meat skewers or again home-made pine pegs that are about five-eighths of an inch square at the top with a 4-inch tapering shank have been used. A spike is used to make the hole for inserting the peg. Sometimes two pegs are placed beneath oblong cups to assure a level seat. Occasionally, conical cups are supported by two pegs or nails instead of being hung.

CUP COVERS

In the United States, with the exception of one type of glass container (fig. 26, *D*), cups are not covered. In India, however, it is customary to place a circular clay cover, with a small segment missing from one side over the top of the cup (p. 159). This cover is held to be of value in keeping out trash and reducing evaporation from the gum.

FACE COVERS

Tests to determine the value of covering the face between chippings with canvas or metal shields have not given any conclusive evidence that such procedure is of sufficient value to warrant its adoption.

WORKING A CROP

After the trees have been selected, the cups hung, and the advance streak cut, the crop is ready for regular working (*311*). This consists in a periodic chipping with a hack during early years, and with a puller when the faces are high above the ground. The purpose of chipping is to freshen the surface of the wound begun by the advance streak. This freshening encourages a more or less continuous exudation of gum. When the cups on the best yielding trees are about full all cups are emptied, the operation being known as dipping. This is repeated several times each season until, at the end of the work in the fall, a second type of collection of the product is usually carried on. This is known as scraping and consists, if the quantity is sufficient to make the collection profitable, of removing the season's accumulation of hardened gum known as "scrape" from the whole face area on each tree. After the final collections of gum and scrape

the cups are raised during the winter in preparation for the gathering of gum to be carried on the next year.

A brief discussion of some of the chief considerations related to each of the above activities is given in the following paragraphs:

CHIPPING

In the United States it is customary to begin at the butt of the tree and chip the streaks successively one above the other (figs. 18, 23,

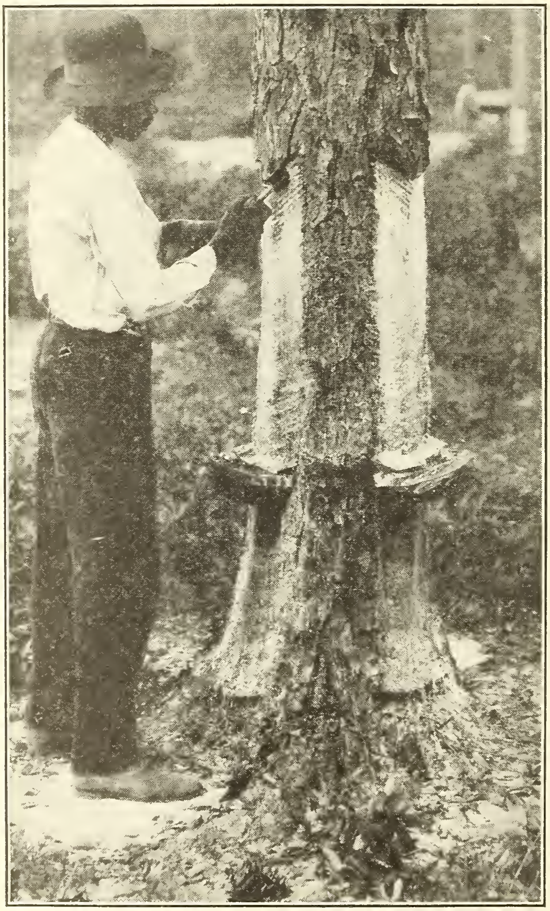

FIGURE 27.—Chipping with a hack. Note the carefully maintained bar of bark between the faces. Oblong clay cups and saw-toothed galvanized-iron aprons are used on this tree.

and 27). Chipping beginning at the top of the season's face and working down has been tried but cannot be recommended on the basis of present knowledge for regular operations extending over a normal period of years.

The shape of the streak, cut into the wood of the tree may vary, but all require that the hack always be sharp enough to make a clean

cut. Three main types (fig. 28) are recognized—the shade streak, the square streak, and the slab or sun streak. The sun streak is favored by some operators since it permits the sun's rays to strike the streak in cool weather in such a manner that the benefit of the extra warmth may be obtained. The shade streak is valued for the opposite effect thought to be desirable in very hot weather. It is also held that with this type of streak the gum tends to run to the outer edge of the streak and drop from the peak to the apron or cup thus reducing scrape formation. The square or slightly shade streak has been found very satisfactory in the Government tests to date.

The angle of the streak also tends to vary. In early work the streaks may be nearly horizontal, although it is more difficult to cut straight across the grain than at a slight downward slant. The slanting direction of the streaks is also designed to cause the gum to flow toward the center of the face and thence down, avoiding possible waste from running over the outer ends of the aprons. A slight slant forming an obtuse angle at the center of the face (fig.

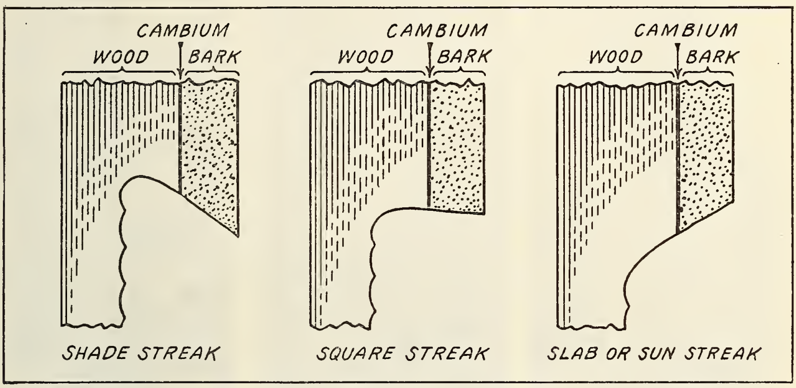

FIGURE 28.—Profile of turpentine faces showing three types of streaks.

24, *A*) is, therefore, held to be good practice. In high pulling the streaks are unavoidably cut on a very marked slant and develop a long pointed peak of wood between them. This wood which is exposed on both sides tends to dry unduly and cause loss in yields, so-called dry facing, which may even result in the complete unproductiveness of the exposed wood. Such a condition would be avoided by the use of the split face (pp. 68, 90) or the double French face (p. 89) if it can be successfully worked out (pl. 4, *D*).

From studies by the Southern Forest Experiment Station it has been found that, as a rule, yields of gum increase with rise in temperature. It appears that rain in itself is not a deterrent to yield but that lower yields usually occur during and after rains because of attendant lower temperatures, and therefore chipping in the rain is not an advantageous practice.

COST OF CHIPPING

The cost of chipping during the period 1925–32 varied from 50 cents to $1.50 for 1,000 streaks. A chipper is seldom able to chip 10,000 streaks or a standard crop each week; in ordinary practice

the number in the crop is frequently only 6,000 to 8,000. Prices paid for chipping vary with economic conditions and with the difficulty of the chipping or pulling or the situation of trees, as for instance when a large part of the crop is in swampy, rough land where wading must be done or when trees are widely scattered.

HEIGHT OF CHIPPING

Only enough wood needs to be removed at each chipping to cut away the dead and dried cells on the surface, to open the resin passages from which the gum exudes (fig. 10), and to keep ahead of the formation of lightwood at the surface of the streak. A satisfactory height for accomplishing this object is about one-fourth of an inch (fig. 29). Distinctly less than one-half inch of wood has served

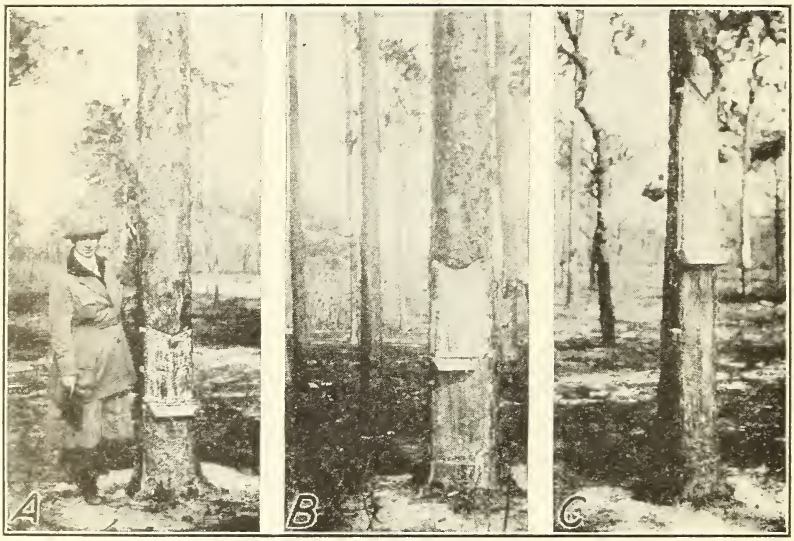

FIGURE 29.—Cutting low streaks, one-fourth of an inch high as in *A*, resulted during the 3 years of turpentining shown, in higher yields and better health per tree than the higher chipping in *B* and *C*, and also reduced the size of the scar on the butt of the tree.

well in conservative chipping. Three streaks to the inch have for a long time been cut on pulling faces, so that markedly less than the former wasteful practice of removing a large hack full of wood is sufficient for the purpose. The old-style high chipping produced less returns per tree and at the same time needlessly reduced the health and growing power of the tree as well as wasting its chipping surface (*226*, *228*, *230*, *565*, *571*). A somewhat higher streak may be cut following cup raising when chipping first begins in spring in order to remove the lightwood, that is, the dried and pitch-soaked wood. This is usually unnecessary when some winter chipping is practiced. In practice attempts to use a streak one-fourth of an inch high have produced faces with a total height of 9 to 12 inches when about 32 streaks were cut, that is, during 1 year's chipping. The habit of low chipping is readily acquired by chippers; yields

and tree health are maintained by this means and at the same time the butt scar on the trees may be greatly reduced or any given tree may be worked for a greater number of years.

DEPTH OF CHIPPING

Care and attention in securing chipping, which is not so deep as to damage the tree but which is deep enough to secure a reasonable exudation of gum, is of basic importance in successful turpentining. Once a tree has received too deep a cut, later reduction in the depth of the chipping cannot fully remedy the damage done on the side of the tree where the deep incision was made. One-half inch deep chipping has been found to be a safe depth to cut into the wood (exclusive of the bark) in most trees and is especially desirable during the first years of an operation when the tree is adjusting itself to increased turpentine production. A streak having its full depth close to the shoulders and a somewhat shallower depth at the peak is also desirable because the most healthy normal conditions and abundant sap are present at the sides or shoulders of the streak. Nevertheless, in young vigorous trees with wide sapwood, growing on good sites, especially longleaf pine ⅝- or ¾-inch deep chipping is often practiced with apparent success. Slash pine appears to be more easily damaged by deep chipping or deep incisions for gutters than longleaf pine. One-fourth-inch deep chipping, while excellent from the point of view of tree health, appears to reduce yields sufficiently to deter operators who have vigorous timber from using such shallow streaks (*571*). Formerly chipping 1 to 1½ inches deep was used, but many trees under this work became unproductive by the second year or even sooner. Deep chipping mechanically weakens small trees and has often been a considerable factor in the damage and loss of trees (*538*) wind-thrown during storms (fig. 30). The setting of gutters and aprons in incisions made in the chipped face is nearly as damaging as regular chipping of the face to the depth of the incision since it severs the sap-conducting channels. Damage from deep chipping is not always immediately apparent. For instance; high yields may be obtained from deep chipping the first year but serious damage, which usually cannot be remedied, may result. The first indications of damage as the result of deep chipping are often found in the narrow layer of the phloem (p. 33) which becomes abnormally dry and reddish brown from being soaked with gum. Even after the streak is red and pitch-soaked, it may yield well for a time. If severe working of trees to obtain as much gum as possible were contemplated it would generally be better to practice deep chipping during the last rather than the first years of the operation.

DRY-FACING

When a face begins to become reddish or darkly soaked with gum or else very white, and gum ceases to exude freely even after a fresh streak is cut, it is said to be dry-faced (pl. 5). The damage produced by dry-facing is in most cases directly traceable to too deep chipping, although too wide or too many faces and long peaks are sometimes contributing causes (*82*, *93*, *239*, *299*, *302*, *361*, *371*, *394*, *442*, *443*, *478*, *514*, *524*). Such conditions interfere seriously with the proper circu-

lation of sap and the normal life activities of the tree. Dry-facing occurs most often in trees with small tops or crowns and in trees with thin sapwood. Abnormal weather conditions, such as result from floods or droughts, especially if associated with adverse site characteristics which upset the natural health of the tree, are frequently followed by considerable dry-facing. Not only are current yields reduced, but the conditions accompanying dry-facing also cause interference with proper tree growth and its occurrence makes the tree more susceptible to infection by fungi and damage from boring insects (p. 133). Some belated improvement in trees damaged by too deep chipping may be secured at times by reducing the depth of the streak cut.

FIGURE 30.—Trees wind-thrown as a result of deep chipping.

LIGHTWOOD

Pine wood that is more or less soaked with gum or pitch so that it is sufficiently inflammable to be readily lighted with a match is known as lightwood. When a streak is cut on a longleaf or slash pine and is left exposed to air, sun, or wind, the wood becomes somewhat dry and the gum not only exudes in drops from the resin passages, but tends to spread from them more or less into the dried wood on the surface of the streak. The streak then no longer looks fresh or white, but becomes somewhat red. This spreading of the gum is often termed healing, or "lightwooding" and serves to distinguish chipping done several days before from fresh chipping.

FREQUENCY OF CHIPPING

WEEKLY CHIPPING

In the United States, as a rule, chipping once a week during the regular season from March to November is widely practiced. This appears to be a fairly satisfactory and safe system as related to the

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A, Saw-toothed apron used with light incision. *B*, Combined gutter and apron for use on small trees. *C*, Use of two gutters set in incisions in wood with flower-pot type cup. *D*, Use of two gutters tacked to a split face with oblong cup.

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DEEP CHIPPING, THOUGH OFTEN PRODUCING HIGH YIELDS FOR A TIME, TENDS TO DAMAGE OR EVEN KILL THE TREES.

A, Incipient dry facing. Wood has become dry and abnormal, and as a result the gum soaks into the wood, darkening it. Failure to exude gum, except close to shoulder, is apparent. *B*, Pronounced dry facing. This results in loss of proper yields and serious damage to tree vitality. The cracks and checks formed in the dry face favor attacks by insects and fungi, which rarely gain access to the wood when it is coated with gum.

general economic arrangement of work in the industry. Although exudation from both longleaf and slash pines varies widely, the chief flow of gum from a freshly chipped streak is usually obtained during the first 24 hours after it is chipped (p. 90).

DOUBLE CHIPPING

Both in practice and in Government and other experiments chipping more often than once a week has been tried. Results to date are inconclusive, and any adoption of an increased frequency of chipping must take into consideration the greater cost of cutting more streaks and the possible extra drain on the vitality of the timber as weighed in the balance against such increases as may be obtained in total yields (*226*). When twice a week or more frequent chipping is applied commercially it is usually done at the height of the producing season in warm weather and during periods of extra high prices. The fact that about 67 percent of the gum from a streak is often obtained during the first 24 hours after chipping and that 80 percent may be obtained during the first 2 days after chipping in warm weather indicates that in an emergency large increases in yields might be secured by decreasing the interval between successive streaks (p. 90).

CHIPPING ONCE IN 2 WEEKS

There is a tradition among turpentine men that excellent yields can be secured from slash pine when it is chipped only once in 2 weeks. Hence, if an operator does not have as many chippers as he can use, he will send them into the longleaf woods first and let the slash go unchipped now and then.

WINTER CHIPPING

Experienced operators differ as to the advisability of absolutely resting the trees as compared with practicing winter chipping. Some successful operators are accustomed to cut one streak, selecting a warm day for the chipping, about once every 4 weeks during the winter. Many hold that yields from such a streak often nearly equal those obtained from one streak cut at other seasons of the year. One reason for the yield thus obtained is that streaks cut during cool weather continue to exude gum for a longer period than those cut in midsummer. Another advantage of winter chipping is that it provides work otherwise scarce at that season. Further, if a streak is not freshened from November to March, a considerable soaking of pitch or formation of lightwood may occur above its surface; this is increased if fires sweep through the stand so that it may extend upward for 4 or 5 inches. This pitch-soaked area must practically all be cut out in the spring before a free exudation occurs from the surface of the streak. A little winter chipping practically eliminates the formation of this pitch-soaked region in healthy, well-worked trees.

The effect of winter chipping on the growing and producing power of the tree during the next season is, however, undetermined. Positive data from continuous controlled tests are lacking in regard

to the exact effect of winter chipping, and as to whether or not it causes undue drain on the producing power of the tree. The fact that the tree is in a relatively dormant condition during the winter, and presumably manufacturing less plant products than during the more actively growing season in warmer weather, undoubtedly has a bearing on the desirability of this practice. It may be quite successful in healthy trees that have been able to store up abundant supplies of reserve materials for building gum, leaves, and wood; whereas it may be harmful in trees that are so depleted of supplies by ordinary turpentining that they cannot endure an additional drain upon their energies. Any bad effects of winter chipping would be emphasized during years when adverse weather conditions prevail. Winter-chipped trees, for example, are often found to be susceptible to attack by insects during periods of drought (*27*). Therefore it appears that the practice of winter chipping should be applied with caution, and only where yielding power and growth of new wood seem well maintained by the trees worked.

OPTIMUM FREQUENCY OF CHIPPING UNDETERMINED

The optimum frequency of chipping for longleaf and slash pine under all conditions has not been satisfactorily determined. It is subject to many variables, the most important ones being weather, species, and type of chipping. Some information is available from Government experiments and from work in foreign countries which indicates that fundamental changes in operating practice are possible. At present, however, other practical considerations appear to be of greater immediate significance. Investigations on varying the frequency of chipping are, however, in progress at the Southern Forest Experiment Station and the Forest Products Laboratory.

PULLING

When the face is about as high as the shoulders of the chipper a hack can no longer be used effectively for chipping, and a puller or cutting tool mounted on a long handle (p. 53) is used for making the streak (fig. 31). The streak cut with a puller is usually narrower than that cut with a hack, for it is very difficult to cut a wide strip of wood with a puller. Frequently the chip cut is less than one-half inch in height; three streaks to the inch of height is common. When pulling, the cutting edge of the puller is caught in the bark at the side or shoulder of the streak and, as the name indicates, is pulled through, cutting away a long chip of wood by virtue of the strength of the man holding the handle.

FACE

The series of wounds or streaks made by the cutting tool (hack or puller) is known as the face. In the United States the regular practice is to begin the face as near the ground as possible, which is usually within 7 to 10 inches depending on the type of cup used. It is lengthened progressively upward season by season for periods of from 2 to 8 or more years until in the latter instance it is usually

so high above the ground that it is no longer practicable to continue the freshening of the streak surface. This type of face is known as the American face.

The sides of the streak at the top of the face next the bark are known as the shoulders. The center of the face where the streaks from the left and from the right come together is known as the peak (fig. 31).

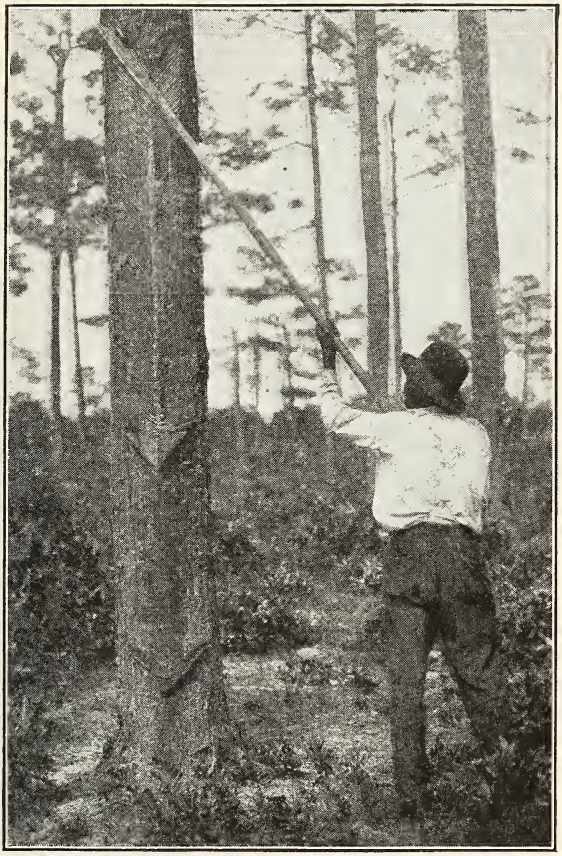

FIGURE 31.—Pulling a fresh streak on a very high face. Note long handle on tool. A chip catcher is attached to the puller stock to catch the wood as cut and prevent the chips from falling into the cup. A long peak at the center of the face is unavoidable in high pulling.

FIRST-YEAR CHIPPING

The face produced by the chipping of the first year is known as the "virgin" face and the first-year crops are referred to as virgin crops. This work is done with a hack. In early times when boxes were used the gum produced during the virgin year was whiter and of higher quality than that from later years which was discolored during exposure as it ran down the long face to the box and hence this finer yield of the first year was given the name virgin.

SECOND-YEAR CHIPPING

The face produced by the second-year chipping, also done with a hack, is known as yearling work.

LATER CHIPPING

The third-year faces are called "buck" faces and those cut the years thereafter are known as "high" or "pulling" faces.

WIDTH OF FACES

American faces are wide. The best commercial work in young second-growth trees generally allows about one-third of the circumference of the tree for the face. This is usually nearly as wide as the diameter of the tree. The width of face is also determined by the length of the streak that can be cut straight through the wood from shoulder to peak without extending deeper than about one-half inch into the wood. Extremely wide faces, as far as experiments indicate, do not increase total yields and frequently reduce the possibility of later yields from back cupping.

In both France and India less wood is exposed in regular turpentining than is the custom in the United States (pp. 145 and 153), but smaller yields are also obtained per face. In France and India it is not until the time comes to cut the trees that a large number of faces, exposing a considerable proportion of circumference are used. A recent effort to introduce a more effective type of face has been made in the United States. It is still in the experimental stage and is discussed in the next few paragraphs.

SPLIT FACE

The shoulder of the streak has long been recognized as a source of proportionally higher yields of gum (p. 90). This fact is most marked when the operation lasts for a number of years because it is then that, as a result of deep chipping or wide faces, many trees dry-face at the peak and give relatively low yields of gum.

The idea of a split face (pl. 4, *D*) having a bar of bark about 4 inches or more wide in the middle, has apparently occurred to a number of people independently at different times (*136*, *226*, *482*). Its purpose is obvious and logical. With 2 narrow, or one-half faces, well surrounded by bark, the face practically has 4 shoulders instead of 2. The faces, at the same time, are well supplied with sap so that they may remain in excellent health during the turpentining operation. Turpentining a living tree unquestionably puts a heavy drain on the tree, hence any means such as this is desirable if reasonably applicable in order not to handicap the tree's activities unnecessarily.

The application of the split face is also based on sound physiological principles. By its proper use tree health and producing capacity can undoubtedly be well maintained. At the same time the method is of distinct advantage in enabling the tree to heal the wound of this small face in a shorter time than is now possible when wide faces are cut. Furthermore, these healthy, gum-covered faces, if

unburned, will probably be safer than the wider faces from the destructive attacks of the turpentine borer (*Buprestis apricans* Herbst) (p. 133).

In attempting to adopt the split face, however, both caution and foresight will be required to assure the best results. It might even be necessary to scribe the boundaries of the faces on the bark of the trees so that on a small tree the total width of wood exposed by the 2 half faces will not exceed one-third of the bark circumference. If the faces become too wide an undue drain would be put on the trees and would result in a similar reduction in profits to that frequently obtained at present by operators who put too many faces on a tree, and as a consequence obtain less yield from 2 faces worked at once than they would obtain from working 1 face at a time during succeeding periods of years (p. 88).

There is danger also of leaving too narrow a bark bar between the half faces. This bar must be wide enough so that the wood under it will not dry out unduly since it is important that it should not cease to function actively as a result of becoming pitch soaked. Unless care is exercised at the first working, some difficulties may be encountered later in finding a good bark space for the faces during the second and third cuppings. It is possible, however, to meet and overcome all these difficulties by utilizing the bark bar for chipping during later working. There is a general impression that such working will require too much supervision and be somewhat more laborious and hence slower than present practice. These features, however, may well be sufficiently offset by increased yields, better tree growth and face healing, to entitle the method to careful consideration (p. 89), especially if two smooth French-type faces are applied instead of American-style chipping (pl. 4, *D*).

NUMBER OF FACES PER TREE

In recent years the practice of working only 1 face at a time has increased. Tests have shown that working 2 faces at the same time on timber destined for continued working does not, as a rule, result in a doubling of the yield to be obtained from 1 face (p. 88). Working 2 faces successively, on the other hand, often results in obtaining from vigorous trees as much or more gum from the back face as was obtained at the first working.

In Government leases it is specified that not more than 1 cup shall be placed on trees from 9 to 14 inches in diameter 4½ feet above the ground, and not more than 2 cups on trees 15 to 24 inches in diameter, and not more than 3 cups on any tree.

Several faces are used in France and India during the last working just before the trees are cut (p. 162). In both countries the faces are narrow and have bars of bark between.

BARK BARS

When two or more American faces are made on a tree, enough live bark should be left between them to insure a free passage of sap and keep the wood supplied with moisture (fig. 27). The width of these bars, also known as " life lines ", should never be less than 4 inches, 6 to 8 is a far safer allowance, although faces have to be

placed with reference to previous scars and to the future placing of back cups. It is important, moreover, that these bars shall be maintained throughout the operation. One of the commonest forms of damage seen in the turpentine woods is the running of faces together in an effort to maintain their width. This results from chipping through the bark bars and is known as "belting the tree." Although it is forbidden, it occurs again and again and results in needless dry-facing of the timber and reduction in yields.

DIPPING

The semiliquid fresh gum that exudes from the tree and collects in the cup is called dip. In the days of "boxes" cut in the tree butts the gum was literally dipped out of the box with a dip spoon

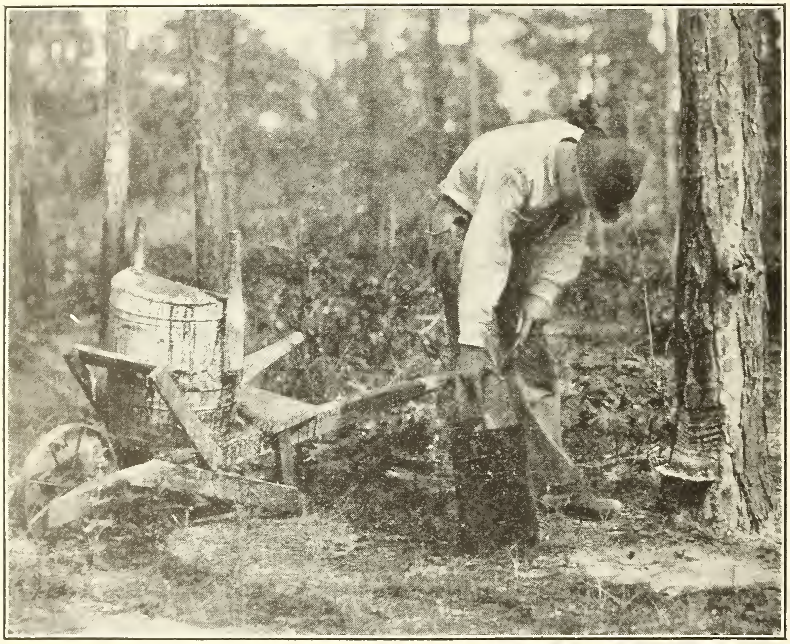

FIGURE 32.—Dipping oblong cup in first-season chipping. Note use of the dip paddle and the well-installed apron low on the butt of the tree.

or dip paddle. Its collection when the cups are full is called dipping. The cups are emptied by detaching them from the trees by slipping them out between the supporting peg or nail and the apron or gutters or by removing them from the nail on which they hang or rest, and carefully pouring off the surface of the gum any accumulation of rain water. The gum is shoved out of the cup with a dip iron or wooden paddle into a dip bucket (fig. 32) and this in turn is emptied into a dip barrel (figs. 23 and 33). It is important that dip barrels should be strong tight barrels to prevent leakage. Wooden barrels similar to those used for gasoline are generally employed, but galvanized-steel barrels are also used

Dipping is done in a crop when a considerable number of the cups are nearly full. If in an emergency dipping is delayed empty

cups are put on the trees which have full cups and the latter are set at the base of the tree or hung on a nail at the side of the face until dipping can be carried out. There are usually 7 to 10 dippings each year from virgin and yearling faces but fewer from buck and high faces. Dippings are generally made about once every 4 weeks, depending on the size of cups, the excellence of the weather, and the producing power of the timber. The more frequent the dipping, the less is the loss from evaporation. Some operators dip as frequently as once in 2 weeks. With low faces not only the liquid dip in the cup, but also any of the partially hardened gum on the face or apron that can be readily punched off with the paddle is collected when the cups are dipped.

The usual pay for dipping during the period from 1928 to 1931 was 65 cents to $1 a 50-gallon barrel. This work is often done by

Figure 33.—Turpentine trees with oval clay cups raised only once, at the end of 2 years of chipping; the man with the bucket is emptying gum into a dip barrel which when filled is loaded upon the wagon to be hauled to the still.

boys or women. Sometimes a crop is rented on shares to a chipper. He is then paid for the work of chipping and dipping, in which his family may share, on the basis of the amount of gum he obtains. This is designed to put a premium on good steady work, prevent waste, and obtain high yields, but it often produces the opposite result because there frequently is a tendency to chip too wide faces and to cut too deep and too high due to a mistaken belief that more gum is obtained by such practices.

The practice of dipping each time a tree is chipped is used in India, thereby reducing evaporation and oxidation of the gum (p. 161).

An analysis by the Bureau of Chemistry and Soils of gum dipped on some of the test tracts of the Southern Forest Experiment Station showed that it contained about 5 to 10 percent of water and 1 to 4

percent of trash by weight (*571*). An examination of trash-free longleaf pine gum distilled shortly after it exuded from the tree showed that it contained 20 to 23 percent of turpentine (*66*). Ordinary dip, which has been more or less exposed in the cup for several weeks, usually contains less than 20 percent of turpentine.

The barrels of gum or dip are hauled from the woods to the still by mule team (fig. 33), automobile truck, or occasionally by railroad.

SCRAPING

The gum that hardens and adheres to the face is known as scrape and contains less turpentine than dip (pl. 6). The collection of this hardened gum is usually made once a year (figs. 24 and 25). Little scrape is obtained from slash pine, especially if the cups are raised each year. With longleaf pine, unless the scrape is regularly collected each time the gum is dipped, usually about 25 percent of the yield is obtained as scrape if cups are raised and as much as 40 percent or more if cups are not raised (*272*, *572*, *573*, *574*, *575*). Many operators remove a considerable part of the scrape during the working season when the cups are dipped. Such collection is known as "punching scrape" and is very good practice. At present scrape is often wasted because pieces crack off or become knocked off the face and fall upon the ground where they may be trodden into the soil or otherwise lost. Moreover, the contact of the scrape with the earth and trash may lower the grade of rosin that can be obtained from it, because contamination often results in darker-colored rosin and rosin grades are judged by color.

RAISING CUPS

It is important that the gum should reach the cup as soon after it has exuded as possible, to prevent waste and undue oxidation of its constituents. One of the chief advantages of the cup system, as compared with the old method of cutting a box in the butt of the tree, lies in the fact that at least once a year it is possible in commercial practice to raise the cup so that it is close to the current chipping.

FREQUENCY OF RAISING CUPS

It has not been found profitable to raise cups more than once each year. Annual raising is practiced by some of the most successful operators, although there are many operators who are satisfied with raising cups only once in every 2, or even 3, years. One of the advantages of low chipping is that cups need not be raised so often as in the case of higher faces. The frequency of raising cups is influenced by such economic factors as the relative value of turpentine and rosin and the difference in price between rosin grades.

COST

It has been estimated that it costs between 1 and 2 cents to raise each cup, although these figures may vary considerably according to the method used.

SETTING APRONS AND GUTTERS IN INCISIONS

Raising cups is one of the most important operations in turpentining, and yet as it is done at present a great deal of damage may result. Where an ax cut is made in the chipped face for the purpose of inserting an apron or gutter when a cup is raised, nearly as much damage is done as if chipping had been as deep as the depth of the incision, because the cut severs cells needed to supply moisture and sap to keep the face productive and healthy. Dry facing, reduced production, pitch soaking behind the face and above it, insect damage, even death of trees, as well as their loss as a result of being split and wind-thrown by storms, are often directly traceable to the incisions made for gutters and aprons when cups are

FIGURE 34.—Deep incisions into the chipped face are eliminated by the following methods: *A*, Gutters tacked to the face; *B*, two-piece saw-toothed aprons inserted in a very light cut under a jump streak; *C*, two-piece saw-toothed aprons inserted mainly in the peak under a jump streak; *D*, *a*, apron and gutter inserted lightly under jump streak; *b*, jump streak used in place of raising cups (ruler at right marked in black and white inch squares).

raised (p. 133). The very light incision required when the saw-toothed aprons are used for raising cups appears to be the least destructive of the processes where this type of raising is employed. Saw-toothed aprons also give a sturdy installation that does not leak (fig. 34, *B* and *C*).

ATTACHING APRONS AND GUTTERS WITH NAILS, TACKS, OR PEGS

Aprons and gutters may be attached to the chipped face when cups are raised by lightly smoothing the surface or chipping a very shallow streak just sufficient to smooth the surface a few inches below the last streak and then tacking the apron or gutter firmly to this surface in such a way that the gum will not leak down the face behind the apron. This method (fig. 34, *A*) is decidedly preferable as far as the life processes of the tree are concerned. The tacks used

for this purpose, however, must drive through galvanized-iron strips without curling; they must have heads stout enough so they will not break off when tins are pulled; they must be easily pulled out and must be rust-resistant to avoid degrading rosin. Finally, they must be long enough to be handled easily. A tack with these qualities has been tried out by the Southern Forest Experiment Station and appears to have met all tests successfully. It is a no. 18 heavy hide tack, cadmium plated with a count of about 190 to the pound. The cost of these tacks (1932) for a crop of faces using three tacks to each tin would be approximately $31. Other tacks or nails are cheaper but usually tear through the tins or have fragile heads that break off leaving the shank in the face to remain a source of trouble to the sawmill which may eventually utilize the tree. Patented devices are sometimes employed which involve the cutting of a shallow gash in the face. The edge of the tin is inserted in the cut and in one type a nail goes through the perforated edge of the gutter to hold it in place. In another type the edge of the tin is held down by a nail with a crimped head. A double-headed scaffold nail can be easily pulled. Another alternative is the use of relatively soft tacks which may be allowed to remain in the tree. With soft tacks aprons have to be perforated as the tacks are too soft to be driven through the metal unless aluminum is used. One of the most ingenious and satisfactory methods of attaching gutters or aprons is that of using wooden pegs (p. 58).

USE OF THE JUMP STREAK

The so-called "jump streak", or "jump peak", leaves a strip of bark about 2 inches high extending across the face at the end of a year's chipping. As used at present it is often substituted for raising the cup. The gum flows to the edge of this narrow shelflike projection and then drops to the apron or into the cup set just below if the cup has been raised. If the cup has not been raised the gum drops to the cup at the base of the face of the year before (fig. 34, *B*, *C*, and *D*). When the jump streak is used the new chipping starts in the fresh wood which has not become pitch soaked or dried out as is the case at the surface of the last streak. It is even possible to insert the apron or gutter in an incision made in the ridge of wood which remains when the chipping jumps from the top of the old face to the beginning of the new one above the bark strip. When winter chipping is practiced one of the disadvantages of the jump streak is that no matter how the strip of wood and bark is utilized it is lost as a part of the yielding area of the face. Moreover, it forms a dead island of isolated wood which may be a liability from the point of view of insect and fungus infection. One advantage resulting from the use of the jump streak has been a reduction of scrape formation as demonstrated in Government experiments at Starke, Fla. (*573*). In longleaf pine, however, scrape tends to accumulate on the ledge of the jump streak and needs to be punched off to prevent waste.

REST PERIOD DURING THE WORKING OF ONE FACE

When turpentined faces are not worked for a year or more, the soaking above the streak is usually somewhat greater than that which occurs as the result of the winter rest. It is known, how-

ever, that trees conservatively worked for 1 year, then allowed to lie out, have gained both in growth of wood and in gum-yielding capacity (fig. 35). As a rule, however, the leasing value of timber

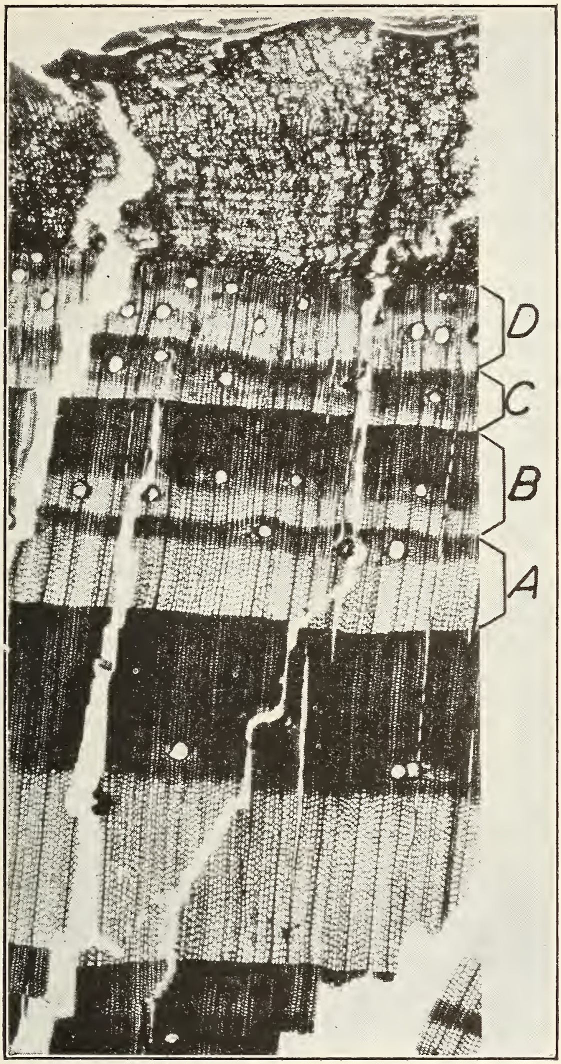

FIGURE 35.—Magnified cross section of a chip from above the face of a turpentined pine. Chipping began in the year that ring *A* was formed and a narrow ring was formed that year due to the turpentining. Then the tree was not turpentined for 1 year. During this rest period, growth, especially the amount of summer wood formed, increased as shown in ring *B*. The next 2 years the tree was again turpentined and rings *C* and *D* were formed. Exceptionally high yields were obtained during these last 2 years in the crop of trees thus treated and represented by this tree. (The white cracks result from the shattering effect of the hack blows when the chip was cut.)

for merely continuing the chipping of faces that have not been worked for a year or more is likely to be lower than that for new front or back faces.

REST PERIOD BETWEEN THE WORKING OF FRONT AND BACK FACES

The first face or faces placed on a round or unturpentined tree are known as front faces. When another face is, at some later time, placed on another part of the tree's circumference, it is called a back face, back cup, or back box. There is a well-founded belief that it is advantageous to rest trees from 1 to 4 years between the end of one working and the beginning of another if possible. This gives the trees an opportunity to recover from the extra drain of the first turpentining and to increase in size. With a larger circumference a better space for later faces is available. Also, if the tree is growing satisfactorily greater resources and yielding power come as a rule with increased size (p. 78).

BACK CUPPING

The act of placing cups on trees that already carry at least one worked-out face is known as back cupping. One or more periods of back cupping are planned in the sustained cropping for naval stores of young-pine stands (p. 109). The leasing value of back cups as compared with front cups or faces varies with circumstances, usually being less. The work of back cupping proceeds exactly in the same way as that of the first cupping. Special emphasis, however, is placed on the leaving and maintenance of adequate bark bars between the faces.

WORK BETWEEN SEASONS

The problem of finding and keeping capable laborers is always before the turpentine operator. It is therefore important to plan work in such a way that a number of workers can be profitably employed during the winter season when regular chipping is not in progress. This is accomplished by carrying on a number of lines of work, several of which are enumerated in the following paragraphs, and also in some cases by practicing the infrequent winter chipping referred to on page 65, as well as the regular work of hanging cups on new crops and raising the cups on crops already established.

TOOL REPAIR

During the winter tools are repaired and assembled; hacks, pullers, axes, and brush cutters are sharpened; dip buckets, cup covers, and mauls are made; and cups are cleaned.

THINNING

Effective thinnings, which will increase the later value of the trees and their yielding power, can be made during the winter (p. 102).

FIRE-PROTECTION WORK

During the winter fire lines should be built or renewed (p. 129). Wherever it is still the custom to rake away the trash and weeds from a 3-foot circle around the base of each tree preparatory to deliberately burning the ground cover during reasonably safe weather, this task offers occupation for the early winter season.

VARIABLES WHICH INFLUENCE YIELDS [18]

A number of variables influence the yield of gum from living pine trees. These influencing factors include (1) tree species; (2) tree development including diameter, crown size and condition, growth rate, and root system; (3) environment comprising competition with other plants for light, nutriment, and moisture, such site factors as soil, drainage, fire frequency, and weather conditions; and (4) the working methods used (*567*, *570*, *571*).

A summary of the available information on the effect of such of these variables as have been studied follows.

SPECIES

SLASH PINE

A comparison of the gum yields obtained from slash and longleaf pines indicates that slash pine is the better naval stores tree under ordinary commercial practice, especially in second-growth stands. It is usually true that slash pine occurs on better sites, under moister conditions, and consequently is not subject to so frequent and repeatedly damaging fires as longleaf pine. This fact may account to some extent for the relative superiority of the slash pine as a producer of naval stores. Serious damage, however, may be done to slash pine growing in wet sites or ponds when the ground becomes abnormally dry and the heavy accumulation of unburned material surrounding the trees catches fire.

Table 8 gives yields of gum from slash pine as determined from sample plots in Alabama, Florida, Georgia, and Mississippi. These yields are based primarily on records from single front-faced trees in their second year of turpentining worked for 32 streaks. For third- or fourth-year work the yields would be somewhat reduced and for first-year work they might in some cases be slightly higher.

TABLE 8.—*Yield for 1 year of gum (dip and scrape) and of turpentine from slash pine trees of different diameters*[1] *for good and poor sites*

Diameter of tree at 4½ feet above the ground	Better than average sites		Poorer than average sites	
	Actual yield of gum per tree	Calculated yield [2] of turpentine per 10,000 faces	Actual yield of gum per tree	Calculated yield [2] of turpentine per 10,000 faces
Inches	*Pounds*	*50-gal. bbl.*	*Pounds*	*50-gal. bbl.*
6	4.7	25	3.2	17
7	6.1	33	4.4	24
8	7.5	40	5.6	30
9	9.0	48	6.7	36
10	10.4	56	7.9	42
11	11.8	63	9.1	49
12	13.3	71	10.2	55

[1] The width of face is one-third of the circumference of the tree in each case.
[2] Converting factor used here is based on analyses by the Bureau of Chemistry and Soils of dip and scrape from Starke, Fla. Scrape represents 6 percent of total yield; trash, 6.7 percent; dip analyses showed 21.5 percent and scrape showed 9.2 percent of turpentine by weight. 1 gallon of turpentine weights 7.2 pounds.

[18] By Lenthall Wyman, Southern Forest Experiment Station, including the results from the work of Austin Cary, Forest Service.

In young slash pines (table 8) every increase of an inch in diameter (5 years' growth or less) usually means a yearly increase of 6 to 8 barrels of turpentine for a crop of 10,000 such trees (*569*).

LONGLEAF PINE

The yields of gum given in table 9 are based on records obtained from longleaf pine in southern Georgia and northern Florida (*98, 566, 571*). Not only do they underrun the yields from slash pine trees of the same size but also the turpentine yields show an even greater difference due to the larger amount of scrape with a low turpentine content (9 to 11.5 percent) formed by longleaf pine (*272, 572*). Fresh gum (dip) has been found to contain 20 to 23 percent of turpentine.

Longleaf pine has some distinct advantages over slash pine in spite of its somewhat lower gum yield, because it is a very hardy tree and capable of tolerating drier conditions, more fire, and heavier chipping than slash pine without dry facing.

TABLE 9.—*Yield for 1 year of gum (dip and scrape) and of turpentine from longleaf pine trees of different diameters*[1] *for good and poor sites*

Diameter of tree at 4½ feet above the ground	Better than average sites		Poorer than average sites	
	Actual yield of gum per tree	Calculated yield [2] of turpentine per 10,000 faces	Actual yield of gum per tree	Calculated yield [2] of turpentine per 10,000 faces
Inches	*Pounds*	*50-gal. bbl.*	*Pounds*	*50-gal. bbl.*
6	4.7	24	3.4	17
7	5.9	30	4.4	22
8	7.1	36	5.4	27
9	8.3	42	6.4	32
10	9.5	48	7.4	38
11	10.7	54	8.4	43
12	11.9	60	9.4	48

[1] The width of face is ⅓ of the circumference of the tree in each case.
[2] Converting factor used here is based on analyses by the Bureau of Chemistry and Soils of dip and scrape from Starke, Fla. Scrape represents 25 percent of total yield; trash 7.4 percent; dip analyses showed 22.9 per cent and scrape analyses showed 11.2 percent of turpentine by weight. One gallon of turpentine weighs 7.2 pounds.

TREE DEVELOPMENT

DIAMETER AT BREAST HIGH

The diameter has long been held to be an important indicator, other things being equal, of the yielding power of the tree. The larger the tree, the larger the yields, broadly speaking. This is mainly accounted for by the current practice of cutting wider faces on larger trees, thereby cutting a larger number of resin passages. A rough criterion of gum yields has been formulated as the relation between diameter and age, that is, when tree diameters are increasing rapidly the gum yields may also, generally speaking, be expected to be high (*402*), although any conclusion based on size alone may have to be modified in consequence of site conditions, spacing, frequency of fire, and weather. Tables 8 and 9 for slash and longleaf pines exhibit the general relationship between yields of gum and the diameter of the trees (*2, 568, 571*). Actual yields may vary depending on other factors, such as soil, season, and methods of working.

In general, it is poor policy to cup trees that are under 9 inches in diameter 4½ feet above the ground because of the relatively low yields to be expected. Such small trees will produce much larger and hence more profitable yields when they have reached a greater size and can also be handled more effectively for future working.

Under some conditions, however, there may be a good reason for working trees even smaller than 9 inches in diameter breast high. For example, many small trees in overcrowded stands may be approaching the period when they will make little or no growth and at the same time they may be retarding the development of the better trees by depriving them of light, water, and nutriment. If these trees can be turpentined so as to pay the cost of working and removal, such a program would materially benefit the remaining trees. Furthermore, many of these trees in overcrowded stands become less and less valuable each year due to suppression by their dominant neighbors. Such trees are becoming increasingly poorer prospects for naval stores and should be worked at the earliest possible moment if they offer promise of a reasonable return even if they are below the 9-inch limit.

CROWNS

The value of a large heavy top or crown in a turpentine tree has been recognized by all who are familiar with naval stores woods work (*195*). On the other hand, stag-topped [19] trees or those with a poor crown development on one side often prove to be poor yielders and frequently dry-face if cups are hung on the side which has dead branches or no branches at all. Such dry-facing is due to lack of sufficient foliage to keep up an active movement of food materials in the tree on the side where the crown is poorly developed. An abundance of dark-green foliage is essential for the adequate formation of gum and wood. It is believed that the crown length of a good turpentine tree should be not less than one-half of its total height although it will be necessary to sacrifice dense stocking per acre in order to produce this type of tree (fig. 36).

RATE OF GROWTH

The current rate of growth in diameter is a fair measure of a tree's vigor. Rate of growth is closely correlated with spacing. The more crowded the stand the slower the growth in diameter. It follows then that higher yields might be expected from fast-growing trees than from suppressed trees. Figure 37, which shows the relation between number of growth rings per inch and yield of gum, substantiates this statement. The trees that grew an inch in diameter every 3 years yielded 30 percent more gum than those which took 8 to 10 years to grow an inch but were of the same diameter (*527*).

ROOTS

Just as a good top is needed in order to supply the elaborated food material manufactured by the leaves which is used in the formation of gum and wood tissue, so also a well-developed root system is

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[19] Trees with broadly branched tops suggesting stag's antlers as contrasted with tapering tops.

essential for the furnishing of adequate moisture, minerals, and other nutriment from the soil to be transformed by the leaves (p. 10). In overcrowded stands there is a continuous competition between the roots of adjacent trees, and the same struggle exists between the tree roots and the roots of the various shrubs, grasses, and weeds that make up the undergrowth in forest stands.

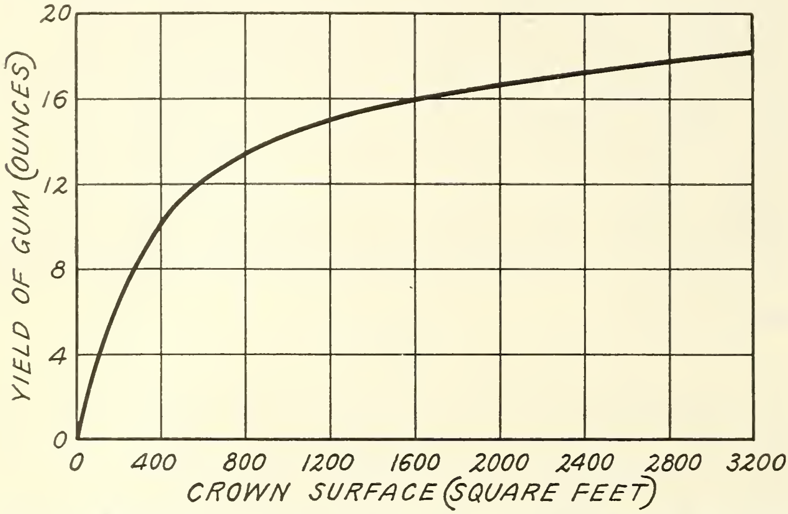

FIGURE 36.—Annual yield of gum per inch width of face during the second year of working in relation to crown surface. Based on 223 second-growth slash pines chipped with streaks one-half inch high and one-half inch deep.

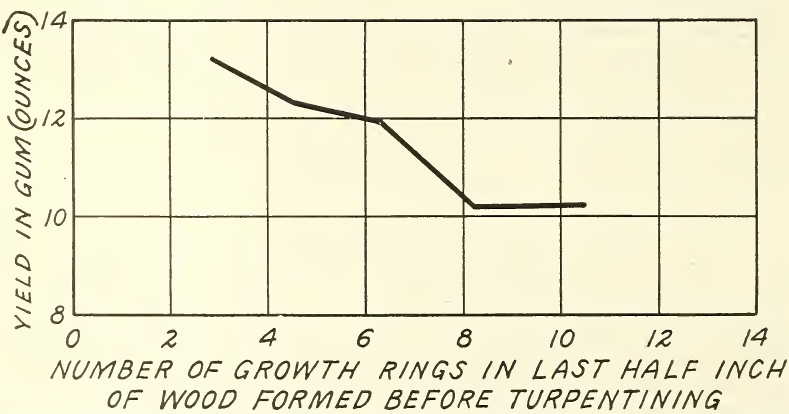

FIGURE 37.—Annual yield of gum per inch width of face in relation to growth rate. Basis 584 second-growth slash pines.

ENVIRONMENT

TREE SPACING

It has been shown in the discussion of tree crowns and roots that plenty of room is needed in order that the tree may grow rapidly and produce the maximum amount of gum. This is natural since both gum production and wood formation are forms of utilizing the tree's

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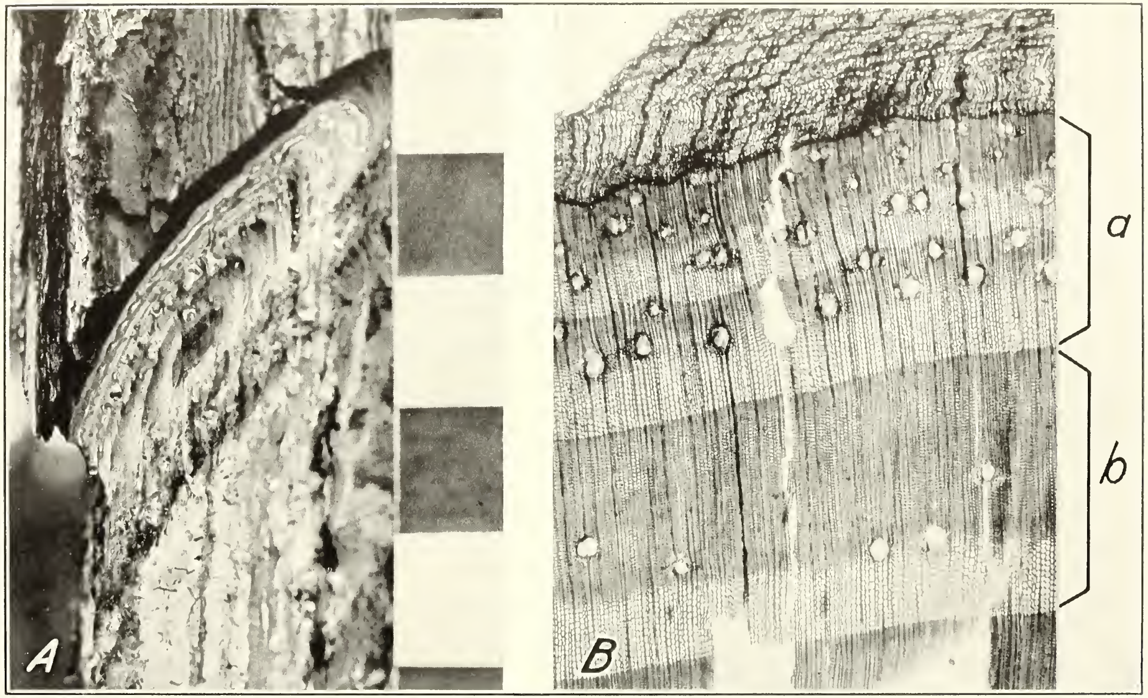
A FACE, HALF OF WHICH HAS BEEN SCRAPED.

Note large mass of scrape at left, such as frequently breaks away from the face and falls upon the ground, where it may be trampled and wasted. The scraped side of face shows that some of the wood is actually cut away by removing the ridges between the streaks. Careful operators arrange to cut a streak or two after a face is scraped so that fresh gum may flow over the face, thus coating it as with varnish to assist in lessening the drying of the exposed surface.



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A, Freshly chipped streak on tree that had been turpentined more than 1 year. Note heavy exudation of gum over the wound wood next bark. Measuring stick marked in inch squares is shown at right. *B*, Highly magnified cross section of wood at the surface of the streak. The two upper annual rings of wound wood *a*, which were formed during turpentining, each contains a larger number of resin passages than the ring of wood *b* formed before the tree was turpentined. The heavy exudation in *A* comes from wood like *a* and the scattered drops from wood like *b*.

manufactured and stored products. The ideal naval stores tree would have a very heavy top but it is essential on the other hand that there be no lower limbs up to 10 feet or so to interfere with the chipping and pulling. Furthermore, a very bushy tree is the poorest sort of tree for lumber production so that it is usually desirable to compromise between the tall, straight, slender, small-topped, clean-trunk tree desirable for high-grade lumber production and the rapidly growing, bushy, open-grown tree that yields the most gum. The maximum monetary return from the timber will probably be obtained from a stand of trees grown for a combination of naval stores and lumber or other timber products (p. 110).

The effect of crowding on the yields of gum has been studied by the Southern Forest Experiment Station. The tests showed that the gum yield from open-grown trees with a stocking of from 75 to 100 per acre was 19 to 31 percent more than from trees in more crowded stands containing 135 to 260 per acre but having the same range in diameters. Furthermore, the decline in yields from year to year as chipping progressed was much less marked in the open-grown timber.

Not only were the gum yields greater from widely spaced trees but also the faces healed more rapidly, showed less dry-face, and the mortality due to turpentining, which may be considerable in dense stands, was less than 0.5 percent annually in open stands.

European experiments confirm the conclusion reached in the Southern Forest Experiment Station tests that yields very inversely with the number of trees per acre (*181*, *189*).

WEATHER

The effect of weather, particularly temperature, on the yield of gum is reflected in the increased production of naval stores during the summer and its practical cessation during the winter. In addition to influencing immediate yields the various weather factors, such as temperature, sunlight, humidity, wind movement, and rainfall, also control the rate at which the tree can elaborate food materials which in turn determines the rate of growth and affects the yield of gum.

Apparently the most important weather factor affecting gum production is the average daily temperature. The two factors which within limits determine the amount of gum that will be obtained by cutting a streak of uniform dimensions on a given tree are temperature and the length of time the streak is allowed to run. When a streak runs for 1 or 2 days only, temperature is of paramount importance. The yield from a streak which is allowed to run for 4 weeks during cool winter days is practically as great as the yield obtained during this same length of time in summer because the streak ceases to yield after a few days when the temperatures are high.

The midseason weekly yield is apt to be 50 percent higher than the yield at either the beginning or the end of the season. Forty to seventy percent of the total yield for the week flows during the first 24 hours after chipping. If the first day's flow is not accelerated by a hot sunny day the entire yield for the week is considerably lowered. Every night the yield slows down and each morning

for several days following chipping it rises again as the temperature for the day increases.

Rainfall, as a rule, is well distributed in the naval stores belt; records at Jacksonville, Fla., covering a period of 55 years show an average of 122 days with measurable rain each year. Ninety of these occur during the growing season of the pine trees.

Prolonged droughts seriously influence the life processes of trees, and, although generally the trees recover after normal moisture relations are established, such conditions may cause the death of large numbers of trees (*117*, *120*, *464*).[20] Dry spells during the producing season are ordinarily accompanied by excessively high temperatures, however, and very good gum yields may be obtained up to the time when the trees actually start to die.

Excessive rains in the flatwoods in the spring may delay the normal warming of the soil and so reduce early yields, or they may also flood the ground around trees for so long a period as to produce conditions sufficiently abnormal and unfavorable to cause the death of the trees.

Other weather factors, such as wind velocity and relative humidity, which influence evaporation and temperature, affect gum yields to a lesser degree.

DRAINAGE

Trees are influenced by drainage conditions quite as much as other crops are, but there is no measure of the effect of drainage or lack of drainage on gum yields. In a general way it is known that trees on well-drained land grow much faster than they do on poorly drained land, and it has been shown that yields of gum are greater in fast-growing trees (p. 79). On the other hand, slash pine trees growing in shallow ponds seem to be able to adapt themselves to this condition so that they often given excellent gum yields. It has been observed, however, that trees growing in such ponds are more apt to dry-face during droughts than are trees that grow in drier situations. Longleaf pines growing on very deep sands that are often deficient in soil moisture produce less gum than trees growing in the moister flatwoods.

SOIL

Although soils have a possible bearing on gum yields, insufficient data are available to state positively which soils produce the best turpentine timber. Drainage and stand density are probably more important factors than soil.

One of the most common soils in the naval stores belt is Norfolk (fig. 5). This is the characteristic sand-hill soil of the coastal-plain region as far west as the Missisippi River (*62*). Norfolk soil is usually a light gray fine sand underlaid by a yellow friable subsoil. Drainage in Norfolk soil is good and often excessive. As a result the driest phases of Norfolk soils are relatively poor sites for longleaf pine timber and naval stores production (*294*). On the other hand, on this soil type under better conditions longleaf pine may make excellent growth. In southern Mississippi and western Louisiana a very similar soil except with a gray mottling in the subsoil occurs.

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[20] WYMAN, L., BARK-BEETLE EPIDEMICS AND RAINFALL DEFICIENCY. U.S. Dept. Agr. Forest Serv., Serv. Bull. 8 (40) : 2–3. 1924. [Mimeographed.]

Orangeburg soils and the closely related Greenville series are also very common in southwestern Georgia and southern Alabama and Mississippi. These soils are composed of a grayish loamy sand overlying a red friable subsoil which occurs at a depth of 8 to 20 inches. The subsoil frequently has pebbles in it. The topography is rolling and drainage is good. Orangeburg soil usually supports a good growth of longleaf pine.

Tifton soils are less common in occurrence. These soils are somewhat like the Norfolk soils. Typically they are light brown sandy loam for 6 to 12 inches under which there is a yellow friable sandy clay. Brownish pebbles often occur. These underlie much typical longleaf pine land.

In western Georgia, southern Alabama, Mississippi, and western Louisiana longleaf pine usually grows on Susquehanna soil. This is

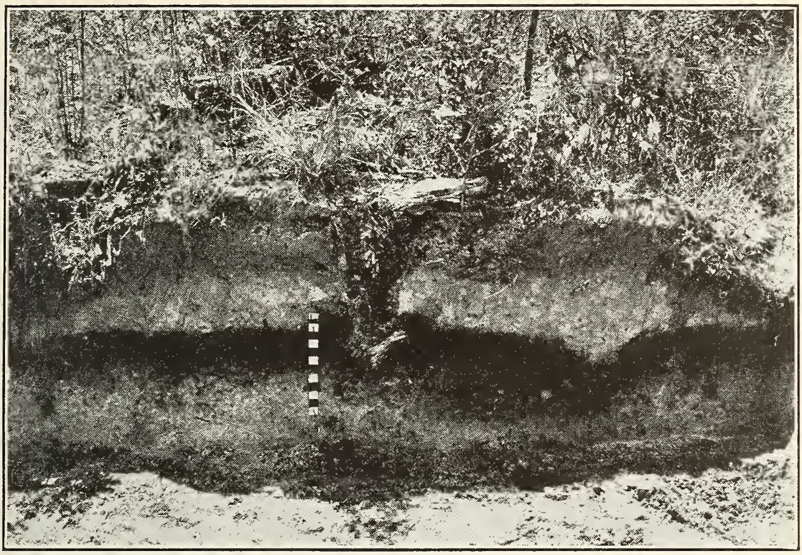


FIGURE 38.—The dark band of earth is the hardpan layer which has checked the normal development of the root shown. (Rule is marked in black and white, inch squares.)

a gray to red sandy loam underlaid at 6 to 15 inches by a stiff red clay mottled subsoil. The topography is rolling to hilly and drainage is good.

Hardpan soils which frequently occur in the flatwoods belt from Florida through southeastern Georgia belong to the Leon series. This soil is typically a light gray fine sand having a dark-brown compacted sandy layer at 12 to 24 inches. This layer is frequently so impermeable that the roots of slash and longleaf pines may be mechanically obstructed and movement of soil moisture restricted (figs. 6 and 38). In general the Leon soils are poorer for naval stores production than the other common soils mentioned here.

Slash pine is more common than longleaf pine on a variety of poorly drained soils with clayey subsoils, such as the Coxville and Bladen series of Georgia, and on soils known as Portsmouth soils which are composed of a gray-black surface sand with a light-gray or mottled gray and yellow subsoil. Portsmouth soils occur in

southern Mississippi and in the flatwoods belt from Florida through South Carolina. Some of the best naval stores timber in the Southeastern States grows on Portsmouth soils.

FIRE IN RELATION TO YIELDS OF GUM

Little data are yet available on the effect of fire on gum yields because few turpentined stands have remained unburned for any considerable period so that yields could be recorded. Severe burning, which defoliates the trees, has been found to reduce yields the following year and cause serious damage to the life and growth of the scorched trees (*110*, *118*, *231*).

OPERATING METHODS

THE EFFECT OF THE YEAR OF WORKING

In the old days, when trees were boxed, yields declined rapidly as the work progressed. This was caused by the damage to tree vitality from the heavy wound made when the box was cut, by evaporation from the face which increased in length from year to year, and by gum being blown off by the wind or being wasted on leaning trees. Even after the cup-and-gutter system came into common use deep chipping, wide faces, and heavy ax cuts for inserting tins resulted in a steadily reduced yield from year to year (*368*). Theoretically, as the result of the wound stimulus, gum yields should not fall off but should increase from year to year if wounding is properly carried out so as not to be too severe a drain upon the trees. Since 1925 a number of successful operators have stated that, with cups raised annually, they often obtain higher yields the second year than the first. Occasionally an operator has stated that his yields are higher the fourth year than the third. This latter result, with ordinary commercial chipping, might merely mean that the weak trees had failed and been culled by the fourth year leaving only the good trees which produced a high yield or that the lower chipping practiced during pulling exerted some influence on the yields.

The yields per crop for 5 years of work on slash and longleaf pines, chipped one-half inch deep by one-half inch high with raised tins, except at the beginning of the fifth year's work, are given in table 10, which is based on the results obtained at the Southern Forest Experiment Station at Starke, Fla.

TABLE 10.—*Calculated annual yield per crop* [1] *of turpentine from slash and longleaf pines for a 5-year period* [2]

Year of work	Longleaf		Slash	
	Barrels	Percent [3]	Barrels	Percent [3]
First	47.1	100.00	52.0	100.00
Second	42.8	90.87	48.2	92.69
Third	46.4	98.51	45.8	88.08
Fourth	40.2	85.35	40.2	77.31
Fifth	32.2	68.37	34.4	66.15

[1] A crop consists of 10,000 faces.

[2] Based on actual yields from groups of young trees on which the tins were raised by making heavy cuts in the face with a broadax, otherwise the yields might have been greater during the later years.

[3] Figures representing the relative percentage of yield obtained by years have been used as a rough basis for the commercial calculation of returns as follows: First year, 100; second year, 100; third year, 89; fourth year, 75; fifth year, 60; sixth year, 50.

The yield of gum (table 10) from longleaf pine trees declined about 15 barrels per crop in 5 years or an average of 3 barrels annually, and that from the slash pine trees fell off 17.6 barrels, an average of 3.5 barrels each year (*571*).

In another series of tests in which tins were tacked on with no deep cuts for tin insertion the yields were maintained much better. In two different groups of slash pines yields were only 10 and 13 percent lower in the fifth year than they were in the first, and one longleaf pine group showed only 9 percent loss. Furthermore, the second year's yield in all three groups was slightly higher than the first-year production, which confirms the reports of some commercial operators. The French also show that the second- and third-year work gives the highest yields and the first- and fourth-year work slightly less (*78*).

PART PLAYED BY WOUND WOOD

The internal structure of the wound wood formed above a turpentined face presents evidence on the possible increase in yields during the second, third, or fourth years of turpentining (*98*). As a rule, this wood is richer in gum-yielding tissue than the normal wood formed by the round timber (p. 33). In vigorous trees the yield, though obtained from all the annual rings cut, is greater from the newly formed rings next the bark (pl. 7). This wound wood, especially adapted to yielding gum, may give a yield 100 or more percent greater than the yield from the older annual rings that were formed before turpentining began. When a rapidly growing tree has been turpentined for 2 or 3 years, a considerable proportion of the streak surface is made up of this wound wood rich in resin passages (pl. 7, *B*). Therefore, if the face is not too wide or the chipping too deep, causing too great a tax on the wound tolerance of the tree or creating too abnormal a drying or damaging of tissue to permit the tree to function, a sustained or even increasing yield of gum should be expected during the later years of the working of any given face. That this condition is not more common indicates that the exploitation now customary is not fully adjusted to the wound reactions of the trees. That yields have been found to increase during the second and third years, should emphasize the desirability of careful attention to wound responses by operators who plan continued working of naval stores pines during several rotations. With more conservative working methods and the abolition of deep ax cuts for raising tins the decline in yields could undoubtedly be materially reduced if not eliminated.

HEIGHT OF STREAK

Every drop of gum taken from the tree represents a drain on its growing power and food reserves. If too much of the specialized tissue with its extra amount of resin-yielding cells is cut away at each chipping the tree will not be able to maintain its producing power at the optimum.

Until very recent years it was the rule for operators to raise the face three-fourths of an inch with each streak, forming a face 24 inches long in a season's work. The work of the Forest Service,

however, has shown that relatively better yields are obtained by reducing the height of streak from three-fourths of an inch to one-half of an inch (*230*, *571*). Moreover, no material loss in yield accompanied an even further reduction in height of streak to one-fourth of an inch with its attendant advantages for longer working or less butt scar on the timber. Most of the tests showed a slightly reduced yield through the use of streaks under one-half of an inch in height in longleaf stands during the first year or two, but this loss was usually overcome by increased production during later years. In addition, the total amount of gum obtained from the extra 3 to 6 years of work, which is possible with ¼-inch streaks, will almost double the returns that would be obtained from ¾-inch chipping and be materially more than can be derived from even ½-inch streaks.

DEPTH OF STREAK

The depth of chipping is one of the most important factors in turpentining. Very deep chipping although it may give high yields for a few years lessens later producing power, and frequently results in the damage or even in the destruction of the timber. On the other hand, within limits, a deeper cut will secure a greater yield than a shallow one. The amount of damage caused by deep chipping will vary with the condition of the timber. Trees that have narrow sapwood must be chipped with shallower streaks than trees with wide sapwood. It is also generally recognized that slash pine timber is more susceptible to damage from deep chipping than is longleaf pine.

There is a great difference in the amount of dry face caused by different streak depths on slash pines growing under crowded conditions as is shown by tests at Starke, Fla. At the end of a 5-year period of chipping 83 percent of the trees in the test groups that were chipped with 0.75- and 1-inch deep streaks were partially dry-faced, whereas only 38 and 28 percent of the trees chipped 0.5 and 0.3 inch deep, respectively, showed any drying. Practically no dry-facing in open-grown young longleaf timber occurred, however, even with deep chipping.

In the tests on slash pine, deep chipping slightly increased the gum yields for 1 or 2 years but over 5 years of chipping the differences in yields from shallow, medium, and deep streaks were negligible. A similar set of tests in longleaf showed that the deepest work (1 inch) gave the lowest yields, whereas the 0.5-inch deep chipping gave the best returns. It is believed that there is little if any significance in the small difference obtained beyond the fact that the deepest work fell off in yield 33 percent from the first to the fifth year, whereas the trees chipped at the other three depths dropped off only 24 percent, probably reflecting the effect of injuring the trees by deep chipping. In the slash pine tests the two deeper styles of work (1 inch and 0.75 inch) caused a greater decline in yields than the two shallower ones (0.3 inch and 0.5 inch).

The progressive increase in the amount of dry face under the deeper style of work coupled with the more rapid decline in annual gum production indicate the likelihood that chipping in excess of 0.5 inch in depth could hardly have been profitably employed over a longer period than 5 years, whereas the shallower work, by maintaining a relatively high yield in the later years of work, could

probably have been used for at least 7 years if the height of streak had been reduced to 0.3 inch. Furthermore, the partially dry-faced trees are likely to be attacked by boring insects and later by wood-rotting fungi (p. 133) still further reducing the strength and vigor of the trees and the value of their butt lumber as well as rendering them liable to windbreak.

For the foregoing reasons it is apparent that the 0.5-inch deep streak is an excellent standard depth for chipping since it produces as much gum as deeper work with less damage to the timber. However, all trees cannot be treated alike. Old-growth timber and small-topped slash pine trees in crowded stands should sometimes be chipped with even shallower streaks to avoid undue injury, whereas large-crowned open stands of longleaf may be chipped 0.75 inch deep without undue risk of injury.

WIDTH OF FACE

The width of the face also exerts an influence on the yields of gum and tree welfare. Although the width of face is partially controlled by the allowable depth of streak, yet there are some chippers who cut unusually wide faces in the hope of getting greater yields. Although the gum yield does increase as the face width increases, it does not increase at the same rate. It is therefore necessary to consider the total yield that can be expected from working a tree with two or three other faces successively, rather than the yield to be derived from working a single face. Consequently, every inch of bark cut away to allow a front face must be reckoned with in planning available space for back facing. An ideal plan of management calls for three faces to be worked in succession, with brief resting periods intervening (p. 74). Exceptions may, of course, occur, as, for instance, trees which need to be removed by thinning, in which case quick removal is the objective and the trees are worked out as rapidly as possible without reference to conserving their vitality for future wood formation.

If, however, the object is to work more or less continuously using three sets of faces during a period of about 25 years it is necessary that the width of face used on the first set be not excessive. In general, about one-third of the bark circumference, or somewhat less on slow-growing timber, is the maximum face width consistent with the foregoing plan. With a height of streak less than one-half inch it is possible to work the front face for at least 7 or 8 years. During this time the tree will normally grow between 1 and 2 inches in diameter and the bottom of the first face will partially heal over. With open-grown trees the healing progresses at the rate of about an inch in 2 years. It is possible then after 1 or 2 years of rest to start a second face of about the same width as the first, leaving a 4-inch bark bar between it and the first face. During the working of the second face the tree will grow another 1 or 2 inches, and after another short rest the third face can be started. In the meanwhile, at least 16 years will have passed since beginning the first face, which, in vigorous unburned trees, is enough time to allow the first face to heal entirely.

If a face width greater than one-third of the bark circumference is used, it will be necessary to allow a longer period of rest following

the working out of each face in order to insure the placing of three faces on the tree or the width of the back faces will have to be reduced. If the wider faces are used they will result in reduced monetary returns because of the delay between workings; if narrow back faces are used the gum yields will be reduced accordingly. If trees have ample growing space and uniform crowns the gum yields from the second and third sets of faces should equal if not exceed that from the front face. Tests on two faces worked concurrently, however, have shown gum yields much less per face than that from single faces worked consecutively (*98*).

In addition, relatively narrow faces result in much less dry-facing and fewer dead trees than where wide faces or double faces are used.

NUMBER OF FACES

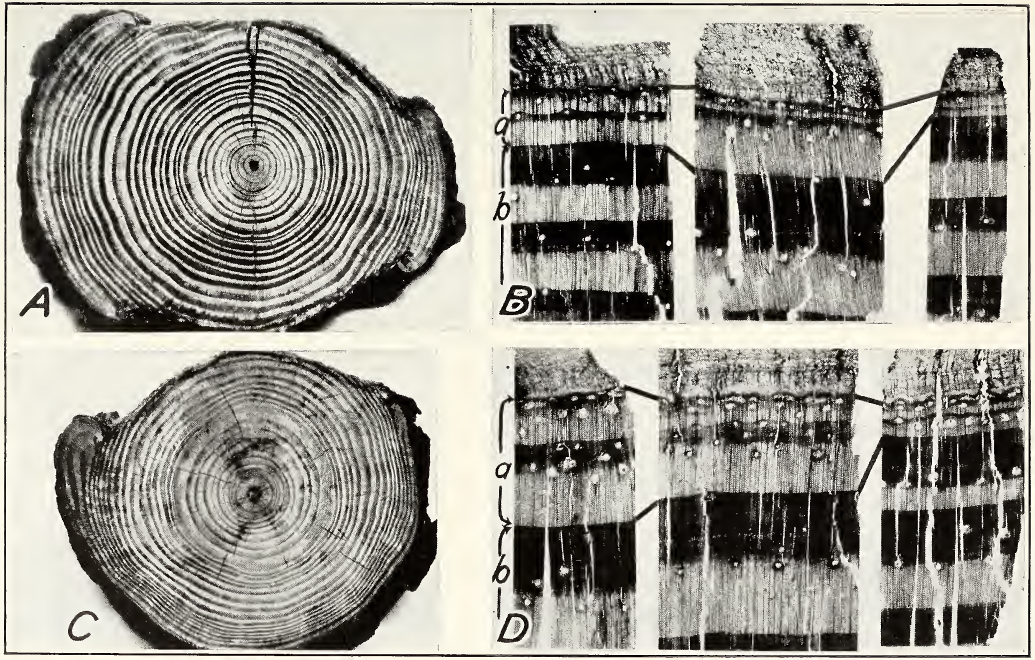
The loss in yield from overcupping small trees has been repeatedly demonstrated (*98*). One striking example is illustrated in plate 8, *B* and *D*. An operator had placed 2 faces simultaneously opposite each other on some young slash pine trees only 10 inches in diameter breast high. This same operator also placed only 1 face per tree on a number of other 10-inch trees in the same crop, and in the immediate neighborhood of the 2-faced trees. Records of the gum yields obtained from matched groups of these 10-inch trees with 1 and with 2 faces respectively clearly demonstrated the present waste and future loss which resulted in the case of the 2-faced trees. Starting with double the gum yield from the 2-faced trees at the beginning of the first year of working, the gum yield by autumn, that year, was already only 30 percent more than that of the 1-faced trees. By autumn, the second year, the gum yield from the 2 faces per tree was actually less than that from the corresponding 1-faced trees, yet the cost of operation remained nearly twice as great. This difference in gum yields is greater than would usually occur, but is indicative of what might be expected as a result of such overcupping in small timber.

The growth, both in diameter and height, of the young 2-faced trees was also checked to a greater extent than in the 1-faced trees (*98*). Only when the greatest return possible is to be obtained in a short time from such vigorous, healthy trees, as in the case of trees shortly to be cut, does the practice of putting two or more cups at a time on a tree appear to be justified.

TYPE OF FACE

At present (1934) the American face (p. 66) is the only style of face in use in the United States, except in an experimental way where the French and split faces (p. 68) are being tested (*273, 367*). Several foreign countries, however, employ the so-called " French face " or a modification of it.

The French face (pl. 4, *D*) is arched at the top, deepest at the center, and is only 3½ to 4 inches wide. It is formed by taking off overlapping thin slabs of wood, progressing up the tree about one-half inch each week but overlapping on the face previously chipped for about 4 or 5 inches. The tools used in France for this work are discussed on page 149. Other types of tools have been developed



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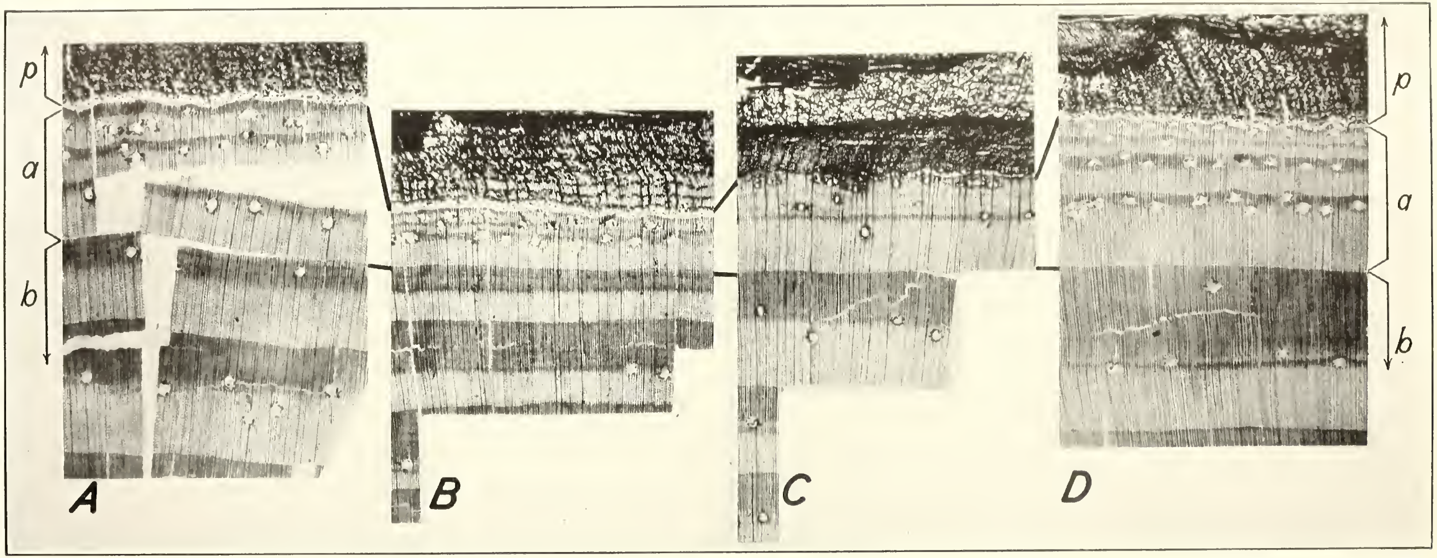
A, Cross section of a young tree showing two faces that were worked at the same time. Note large proportion of the circumference removed by this method, which causes a very severe drain on the tree's vitality, especially when applied to trees as small as that shown in *C*. *B*, The damaging effect of working two faces simultaneously is shown by the internal structure of the wood above the face at midstreak in the trees which were turpentined for 2 years. Note the two narrow rings with comparatively few resin passages in the wound wood next the bark in region *a* as compared with the normal wood in region *b*. *C*, Cross section of a young tree turpentined with one face. *D*, The structure of trees (of the same size as shown in *B*) where only one face was used is shown in regions *a* and *b*. By the end of the second year the trees with one face *D* were exuding as much gum as those with two faces *B*, cost half as much to operate, and left space for later profitable working.



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PHOTOMICROGRAPHS OF CROSS SECTIONS OF CHIPS CUT FROM MID-STREAK OF TWO MATCHED PAIRS OF HIGH OR LOW YIELDING TURPENTINED PINES.

The beginning of the first year of turpentining is used as a base line. The area, *a*, above this line in each specimen is the wound wood formed during turpentining. The area, *b*, below the line is made up of normal wood formed before turpentining began. The inner bark or phloem is shown at *p*. *A* and *B* show the structure of an externally matched pair of longleaf pines. *A* produced almost twice as much gum as *B* and had wider rings. *C* and *D* are from an externally matched pair of slash pines. As sometimes happens, wood formation in *a* of *C*, the high yielder, was reduced and high gum yields were produced at the expense of wood formation

at the Southern Forest Experiment Station which promise to be better adapted for use by American labor when chipping this type of face on trees smaller than 11 inches in diameter (p. 51).

A test of the relative efficiency of the American hack and the French chipping tool on the same longleaf trees was made by the Southern Forest Experiment Station. It showed for a 2-year period that the French faces yielded from 16 to 22 percent more gum than the American faces of the same width (*273*). Much of this advantage was lost during the third and fourth years of work because no satisfactory tool for high faces had been developed. With the tool used, the depth of face was reduced, with a corresponding decrease in yields. The total gum yields for 4 years of French-style chipping were only 7 percent greater than the yields from American-chipping methods. On slash pine the French faces produced relatively higher yields than American faces, in proportion to the width of face for the first 2 years of working. The actual yield per crop of faces ranged from 17.1 to 21.5 barrels of turpentine. It is possible, however, to place a pair of French faces on a tree so that they will drain into a single cup and thus obtain yields of 38 to 39 barrels per crop of 10,000 cups or 20,000 small faces. This would require no more scarring than would be caused by using 10,000 American faces each 8 inches wide (pl. 4, *D*). The narrow face is a distinct advantage with respect to healing so that not over 8 or 9 years should be required in thrifty young trees to heal completely over the two 4-inch French faces, as compared to 15 or 16 years for a single 8-inch wide American face.

FIGURE 39.—Split face with American chipping as used in tests conducted by the Southern Forest Experiment Station.

Split American faces (p. 68) are essentially American faces in which the two streaks do not meet at the peak but leave about 4 inches of bark to separate the halves of the face (fig. 39). It has been reported (*136*) that these faces yield somewhat more than single American faces with the same amount of wood exposed because of the elimination of the relatively unproductive peak and the closer proximity of all parts of the streak to the active flow of sap and food materials. Observers believe that, at least in the case of wide faces which have been worked for some years, more than 50 percent of the yield comes from the tissue within about 2 inches of the shoulder. The split faces also promise to heal over more quickly because they are narrow. Such faces, however, require much care in installation and close supervision during operation. They have not proved so satisfactory on large trees, all things considered, as on small trees.

FREQUENCY OF CHIPPING

The proper interval of time between streaks is a matter of importance, although practically it is difficult to adjust costs and laborers' tasks so as to take the best advantage of even our present knowledge. Theoretically, a second streak should not be cut on a tree until the gum has essentially ceased to flow from the preceding streak. This time is determined by the weather and varies from 3 or 4 days in the summer for longleaf to 3 or 4 weeks in the winter for slash. The rate of gum flow steadily declines after the first exudation (*286*) if the temperature and other weather factors remain constant (table 11). During the hottest weather longleaf pines produce about 83 percent of the total gum yield for a week during the first 24 hours following chipping. The corresponding figure for slash pine is about 64 percent. In cold weather only about 23 percent of the yield for a week is produced by longleaf pines on the first day and 9 percent on the seventh day. For slash pines the figures are about 15 percent for the first day and about 8 percent for the seventh. Slash pine also shows a tendency to flow for a longer period than longleaf.

TABLE 11.—*Daily yield of gum from slash and longleaf pine for a week in which the mean air temperature was 76° F.*

Day	Slash pine	Longleaf pine	Day	Slash pine	Longleaf pine
	Percent	*Percent*		*Percent*	*Percent*
First	52.8	74.1	Fifth	4.9	2.2
Second	19.5	12.1	Sixth	4.0	1.9
Third	9.1	4.8	Seventh	3.4	1.7
Fourth	6.3	3.2	Total	100.0	100.0

In practice a streak is cut once a week from March to November and either not at all or about once in every 3 or 4 weeks from November to March. Occasionally streaks are cut twice a week in midsummer. Such practice takes partial advantage of the physiological response of the tree to weather conditions. To take full advantage it would be necessary gradually to reduce the chipping interval to 3 days in July and August, then increase to 4 days in

September, 5 or 6 in October, 7 to 10 in November, and 10 to 30 days in extremely cold weather. The process would be reversed in the late winter and spring. If trees are chipped again before the gum flow has ceased from the preceding streak, the rate of flow may be speeded up and a greater total yield obtained, but the yield per streak will be reduced and the cost of chipping thereby increased. On the other hand, an increase in total yield will reduce the prorated overhead charges per barrel of gum because they are distributed over a larger production. Moderate double chipping (twice a week) has not appeared to affect adversely vigorous young trees where it has been practiced, nor is it believed that careful winter chipping has a bad effect. Winter chipping, if the streaks are not cut too often, undoubtedly has been found to yield enough gum to make it worth while to numerous operators (p. 65).

CHARACTERISTICS OF HIGH-YIELDING TREES

High yields of gum are obtained in general from trees which receive ample light, warmth, optimum moisture, and are free from undue root competition. Such trees are openly spaced, have long bushy crowns bearing dark-green thickly set needles, are growing vigorously, and have a rough, scaly bark (*98*). After they have attained a diameter of 10 inches or more at 4½ feet above the ground, profitable yields may be expected when stands of such trees are turpentined by modern conservative methods, provided normal weather conditions and ordinary freedom from burning or insect and fungous infections prevail (fig. 40, *A*). Such trees have been known to fill their cups 2 or 3 times before the cups on ordinary trees less favorably situated and developed have been filled once.

This general diagnosis, however, does not suffice in all cases for the positive selection of high-yielding individuals, as is found wherever records have been kept of the gum yields obtained from individual trees. It is clear that all the significant basic factors which determine the production of gum are not yet sufficiently understood. It is not yet possible to explain, for example, why a misshapen runt sometimes yields more gum than a fine, symmetrically developed neighbor of larger size (fig. 40, *B* and *C*). Or again, trees are sometimes found which appear alike in all external characteristics but vary widely in gum production. Under the same operating methods such like-appearing trees (fig. 40, *D*) frequently vary as much as 100 or even sometimes 300 percent in the amount of gum exuded in a season. Already, however, certain tendencies and conditions have been observed in microscopical studies, which appear to be associated with the production of relatively high yields (*12*, *44*, *229*, *344*, *345*).

The externally vigorous trees, as a rule, have relatively wide sapwood and annual rings, produced both before and during turpentining. This characteristic, as has been shown, is usually associated with good gum producing capacity, as indicated in figure 37 and in figure 40, *A*. The width of the annual rings, however, is frequently adequately disclosed only upon an examination of the internal structure from a chip or increment boring (p. 113). This, for example, was the case in the pair of longleaf-pine trees

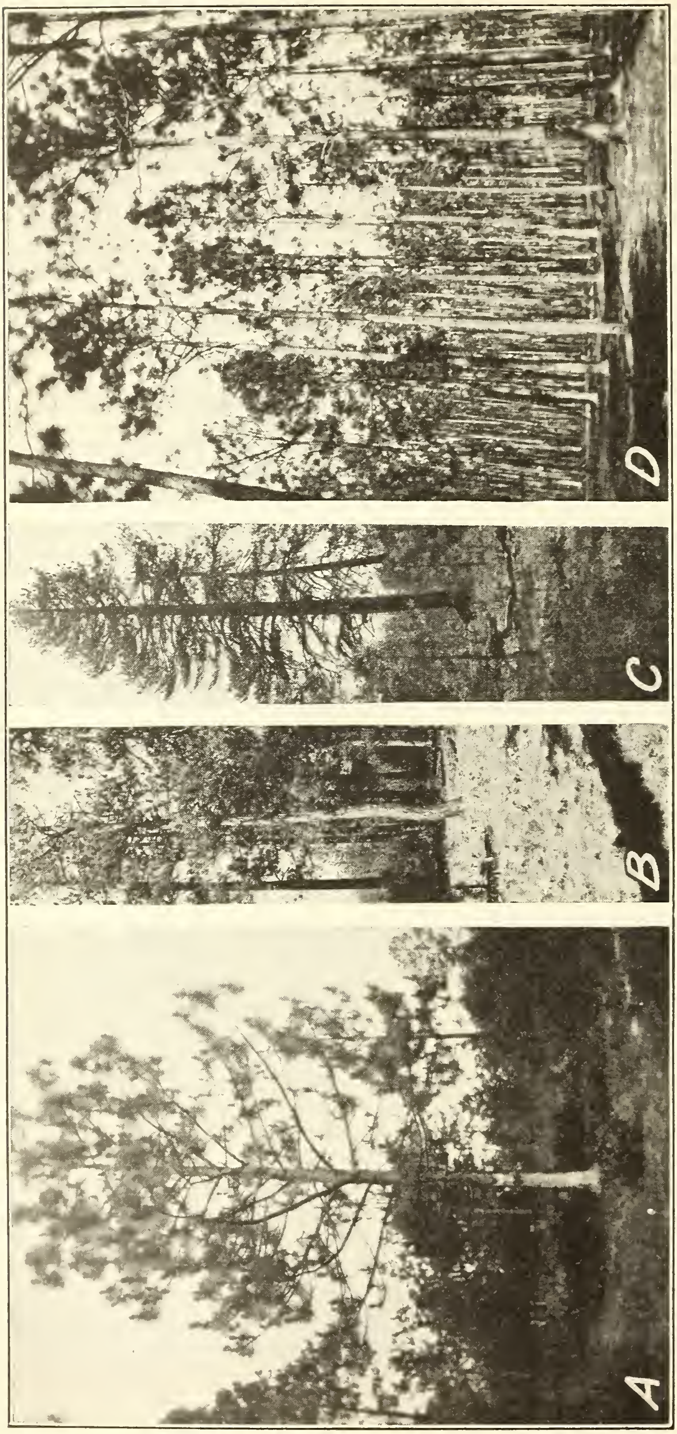

FIGURE 40.—*A*, Typical open-grown, large-crowned tree that gave high gum yields. *B*, The small crooked tree yielded more gum than the large straight tree shown in *C*. *D*, The externally matched pair of longleaf-pine trees in the center showed a wide difference in yields. The internal structure of these two trees is shown in plate 9, *A* and *B*.

illustrated in figure 40, *D*. These trees were 9.7 inches in diameter at breast high when turpentining began in 1926. The lower yielding tree, which produced only about half as much gum as the high yielder, is at the right in figure 40, *D*, and was 62 feet tall and had a crown 13 feet wide and 26 feet long. The higher yielding tree was generally similar, being 65 feet tall and having a crown 11 feet wide and 30 feet long. The wood structure of chips cut at the streak on these two trees, however, differs. Plate 9, *A* shows the appearance of the wood of the high yielder and plate 9, *B* shows that of the low yielder. The high yielder had wider annual rings both before turpentining began and also during 3 years of turpentining. In addition the inner bark or phloem (*p*) close to the cambium of the high yielder, is fully stocked with stored reserves, as is shown by its dark contents, whereas the similar area in plate 9, *B*, is light because of its relatively empty cells. It would appear that the high-yielding tree was able to store and assimilate the products of its growth activities more successfully than its similar neighbor.

An interesting exception to the general rule of direct association between ring width and yields is illustrated in plate 9, *C* and *D*. These are photomicrographs of the structure of the wood taken at the producing surface of the streak in two closely similar slash-pine trees that had been turpentined for 4 years at the time the photograph was made. In 1925 both the trees were 8.2 inches in diameter at breast high, a size below that recommended for regular turpentining. Each tree was 60 feet in height and each had a crown 22 feet in length, yet the tree represented by *C*, plate 9, produced almost twice as much gum as that shown at *D*.

It would seem that tree *C*, taxed by the turpentining beyond its wound tolerance, produced a large amount of gum at the expense of wood formation, making it clear that, although in general wide rings are correlated with good yields of gum, the converse may not always be true; that is, excessive stimulation by severe wounding, such as turpentining small trees or trees with the foliage scorched off by fire (p. 84), may lead to the production of wound-induced cells which yield much gum but make very little normal woody tissue. The response of tree *C* with its narrow rings and poor summer wood in the area formed after turpentining, is closely analogous to the driving of a free-running horse to death as compared with the more moderate speed under the whip which is obtained from a less responsive individual as represented by tree *D*.

The selection of high-yielding trees can, it would seem at present, be further realized by eliminating the trees which are already known in general to be typical low yielders and a business hazard, the operation of which tends to encroach on the profits to be obtained from better trees. Characteristics of low-yielding trees include small diameter, the size being due to the fact that the trees are either very young or very old, slow growing, and suppressed. Very small crowns, such as occur in crowded stands, indicate trees which can scarcely maintain ordinary wood formation much less respond successfully to the additional drain of turpentining. Such trees usually have relatively unfurrowed bark, narrow sapwood, and very narrow outer annual rings before turpentining has begun, which are the result of insufficient light, nutriment, and moisture. Low-yielding

trees also occur on very dry sites or very wet and poorly drained swampy sites where considerable water stands in rainy weather, but which become exceedingly dry and unfavorable during dry periods so that dry-facing and death of turpentined trees frequently result.

The best guides, therefore, on the basis of current information, that can serve in estimating the yielding capacity of a stand are (1) size of trees (minimum to be cupped 9 to 10 inches unless for thinning the stand for the purpose of future rather than present profit); (2) vigor of growth, as shown by external appearance of the crown; and (3) the width of the sapwood and especially of the outer annual rings recently formed.

FOREST MANAGEMENT FOR SLASH AND LONGLEAF PINE LANDS [21]

No region of the United States today shows a better opportunity for sustained yield and profitable forest management than the naval-stores belt (*97*, *115*, *186*). While in many regions and countries forest-management plans must extend over rotation periods of 100 to 150 years or more, in the naval-stores region of the Southern States it is possible to establish a new stand and harvest it, within the period of active life of the owner, say from 25 to 60 years. If properly handled, moreover, such stands will be capable of maintaining and even increasing the past volume of naval-stores production, as well as supplying such commodities as firewood, poles, piling, pulpwood, railway ties, timbers, and lumber (*7*, *83*, *96*, *99*, *108*, *112*, *115*, *116*, *133*, *164*, *166*, *187*, *188*, *246*, *247*, *248*, *249*, *250*, *261*, *262*, *263*, *284*, *287*, *580*).

The actual management of a slash-longleaf-pine forest is comparatively simple. Essentials, as determined by study and experience, are indicated in the various examples presented in the following pages. The recognized objective of a management plan is the obtaining of the greatest net financial return per acre per year on a sustained-yield basis.

PROPERTY SURVEY AND INVENTORY

The first step in organizing a forest property for systematic management is to make a survey and an inventory of the timber resources. The inventory should show the number of trees by species, by age classes, and by diameter at breast height. The rate of diameter growth should be established for trees by species and by diameter classes. The number of trees under operation, with the height of faces, should be determined, together with the number of trees still standing, upon which turpentining has been completed. A map should be made showing location of boundary lines, roads, highways, and railroads, streams, swamps, and barren areas; location and area of crops—active, idle, and abandoned—forest types, areas of young growth, and the like (*187*, *261*).

From this information and a practical knowledge of the needs, possibilities, and limitations of the turpentine and logging business,

[21] Compiled chiefly from the work of Austin Cary and W. R. Mattoon, branch of public relations; I. F. Eldredge, division of forest economics; and various members of the staffs of the Forest Products Laboratory and the Southern Forest Experiment Station by Eloise Gerry, Forest Products Laboratory.

the owner is in position to appraise the possibilities of the situation and make plans for systematic management designed to give the greatest possible returns per acre.

Not all ownerships are suited for the immediate application of sustained-yield operation; some areas are too small, some do not have a favorable distribution of age classes in their timber stands, some have timber or land of such poor quality as to present a poor chance, and some are impossible because of financial burdens already fastened upon them. It is only after a careful consideration of all the facts as disclosed in such a survey that the attractive possibilities can be separated from the poor or indifferent chances.

DETERMINATION OF LENGTH OF ROTATION

Deciding upon the length of rotation; that is, the time required to grow to usable size for final products the type of trees desired for a given stand, is a second feature of importance in formulating a working plan; for although the length selected may be modified by unforseen future developments, it is desirable at the outset to have a definite objective that offers good promise to work toward.

When stands are to be managed primarily for naval-stores production, which is the chief consideration in this discussion, they require different treatment from that which would be given them if they were being grown primarily for the production of the best saw timber or for pulpwood. In many stands, however, it seems probable that compromises will be made to permit a profitable production of wood products as well as naval stores. For naval-stores production comparatively short rotations of about 20 to 30 years, followed by the removal of the worked trees, may be used under favorable conditions. Rotations of about 45 to 60 years, however, seem to promise rather better for stands where the objectives include both the production of the greatest quantity of naval stores per acre at the smallest cost in the shortest time and minimum damage to the remaining wood-product values (*187*, *533*).

SIZE OF HOLDING AND ITS OPERATION FOR CONTINUOUS YIELDS

An important objective for forest management is the building up of a holding of sufficient size to insure a profitable production of sustained or continuous yields.

For large-scale operations the number of trees turpentined annually should be such that continuous yields from workings of different ages should so supplement each other that new trees will be ready for chipping when the work on older crops is finished and the worked trees are not in use, either during rest periods or because they have been worked as long as it is deemed profitable, and are to be converted into other products. This procedure resembles that used by the French, which is graphically illustrated in figure 41. Under the French system, turpentining is begun when trees are 25 to 30 years old. Using figure 41 as an example to illustrate the principle of continuous operation, a sequence such as that indicated would be used. The operator would be turpentining the even-aged stands in each of the lots or units marked 6 to 14, inclusive, in figure 41. Each lot would contain a number of crops, the number depending on the

size of the lot and its stocking. The stand on a given lot would usually be of different age from the stand on any other lot, although lots 8 and 9 are examples of stands of the same age. Lots 1 to 5, inclusive, would be covered with trees too small for regular working, and lot 15 would represent the stands on which turpentining had been completed and the mature trees had been turned over to the loggers. Every 5 years or so turpentining would be commenced in the oldest unturpentined lot (lot 6) and discontinued in the oldest turpentined lot (lot 15). Under such a plan the operator would always have about 9 out of 15 lots being turpentined or enjoying a temporary rest between workings, and about 5 lots of young trees growing in preparation for assuming their place in the turpentined group. One lot or area (several crops) under this plan would each year be cut and restocked. The actual number of crops worked under such a plan might well vary from as few as 2 or 3 to as many as 100 or more according to the stands available. As in these large-scale

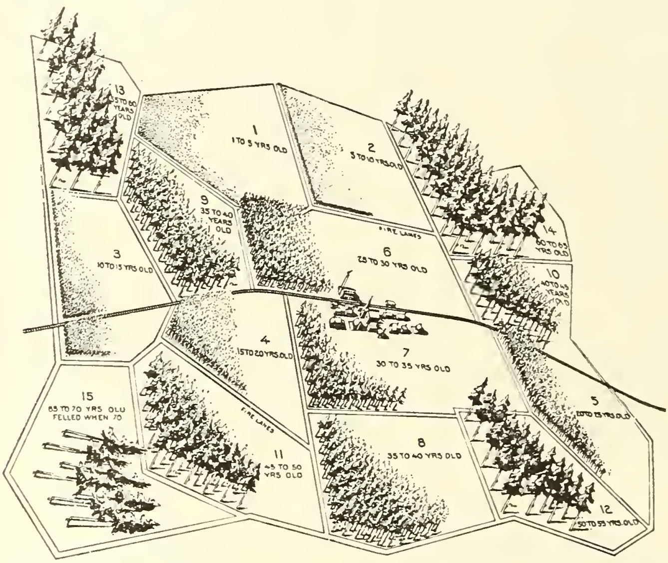

Figure 41.—Perspective diagram illustrating the system of management of a French turpentine farm for continuous production. The numbered lots of indeterminate size (1 to 15) are each covered with the size and age of timber indicated thereon. (The sketch is not drawn to scale.)

workings, so also it is possible on very small tracts on farms to apply similar basic procedure. The gum obtained on small holdings, which could not economically conduct their own still, may be sold to neighboring stills. This practice was common many years ago and is again being adopted.

The forest-management plans used in France, such as the one illustrated in figure 41, are applied as a rule to even-aged stands; the existence of such stands, adequately distributed as to age classes, is, however, less common at present (1934) in the second-growth forests of the United States. Therefore, the direct application of the French-management system would not be possible until there exist more generally well-stocked, even-aged stands, with each age class properly distributed as to area. The essence of the plan, however,

that is, the working and reworking of trees over a period of years, often through three successive workings, to secure high production per tree, has already been carried on, though often very roughly, in the existing young pine stands in the South (fig. 42). Results from such handling can undoubtedly be greatly improved as time goes on and the more ideal condition resulting from widely distributed, fully stocked, even-aged stands is approached. Some examples bearing on these procedures are given in the following pages.

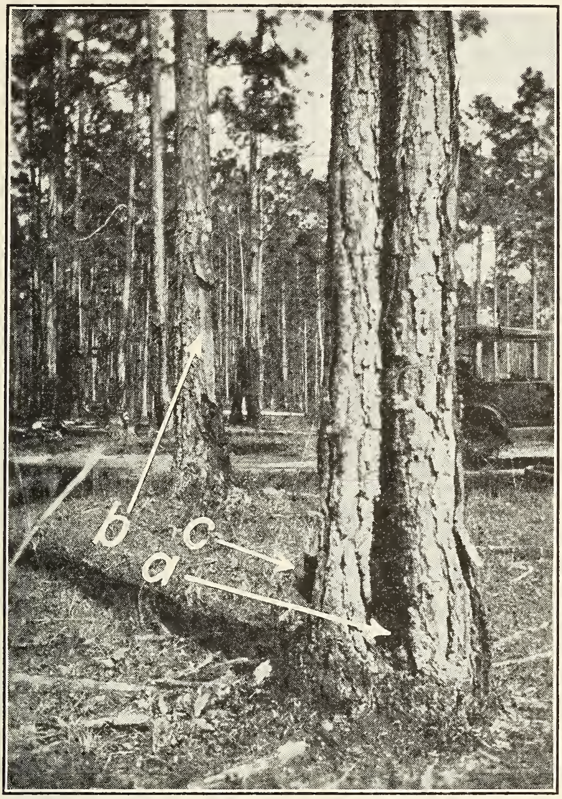

FIGURE 42.—A stand of young slash pine being turpentined for the third time. Note first working, *a*, box in the foreground; *b*, the second face, the working of which has been completed, is shown on the tree at the left; and *c*, the third working, just begun, is indicated by the gutter on the back of the tree in the foreground.

EXAMPLES OF MANAGEMENT PLANS FOR A SUSTAINED YIELD OF NAVAL STORES AND OTHER PRODUCTS

MANAGEMENT PLANS FOR EXISTING STANDS

Existing slash and longleaf pine forests may include trees which exhibit almost every conceivable variation in age, size, development, and condition with respect to site and to chipping for naval stores production. To illustrate some of the variables involved, it is possible to have the two species of pines mixed in varying proportions; to have remnants of the original forest growth trees standing beside young trees unworked or already chipped for turpentine, as well as

somewhat damaged by fire, decay, and insects; and very generally to include trees of old field growth together with forest growth, some located on dry, sandy ridges in the same crop with trees standing in swamps or ponds which may contain surface water throughout the year. Moreover, on part of the land the trees may stand 5 to 15 to the acre and have large, bushy crowns, whereas in another part of the crop they may grow in very dense stands, varying in number from several hundred to several thousand young trees per acre.

These uneven-aged stands require specific treatment which depends upon the type of trees present (*198*, *431*, *432*, *438*, *448*, *504*). For example, if there is a sparse stocking of young trees growing under a dense stand of older trees, the young understory is of little importance. On the other hand, if the old trees are not very numerous and the young, desirable trees are getting a good start, it will frequently be best to remove the older trees to encourage the best development of the younger ones. It is possible to grow two age classes at the same time on the same area; but it is impossible, without sacrificing rapidity of growth and desirable form of crowns, to grow as many trees per acre in either class as can be grown when the acre is stocked with one-age class alone.

The following example illustrates a plan of management for a comparatively simple situation, together with estimated costs and returns (*533*).

MANAGEMENT EXAMPLE 1

The basic forest information used in this example was obtained from forest surveys made in northern Florida. The stand table and rate of growth are both based upon the better classes of forest land, such as would be chosen for intensive management. The forest portrayed is an all-aged stand made up of definite groups of longleaf and slash pine in which, at the beginning of management, 59 percent of the trees were longleaf and 41 percent were slash pine. The ages ran from 1 year to 50 years. The diameters at breast height ranged from less than 1 inch to 16 inches. The stand per acre at the beginning of management had 283 trees, distributed as shown in table 12.

TABLE 12.—*Distribution of trees in stand used in example 1*

Character of stand	Number	Percentage
Seedlings 2 inches or less in diameter	145	51.3
Saplings 4 to 8 inches, inclusive, in diameter	96	33.9
Turpentined trees 10 to 14 inches, inclusive, in diameter	40	14.1
Saw timber 16 inches or more, inclusive, in diameter	2	.7
Total	283	100.0

The rate of diameter growth assumed is 0.31 inch a year which was the rate found generally on the better sites in the locality where the study was made. This is conservative, as no increase is made on account of the improved growth conditions to be expected under management.

The plan outlined is for the management of this forest on a 48-year rotation, with a turpentine cycle of 8 years. The stand is

to be thinned at the beginning of each 8-year period; the young trees, 3 inches and under in diameter, standing as is customary in thick clumps scattered over the area in openings left by the removal, in previous operations, of the larger worked-out saw-timber trees, are to be thinned to an average stand of 80 trees per acre. At the beginning of management and in the eighth year thinnings are necessary; in the sixteenth year and every eighth year thereafter the 8- and 9-inch trees, in addition, are to be thinned to 25 trees per acre. Before the 8- and 9-inch trees to be removed are cut, however, they are worked for turpentine for 8 years. At the beginning of each 8-year cycle, the trees that have reached 9 inches in diameter at breast height are worked for turpentine under a conservative long-time method by which only one face is worked at a time. The first face is worked 7 years at the rate of 12 inches in height per season. After a rest period of a year the second face is started and carried for 7 years; there is another rest of 1 year, and the final face is placed and worked for 7 years. Then the tree is felled for saw timber or other products. It is assumed that the opening resulting from the felling will restock naturally to pine seedlings. The first thinning when the trees are between 6 and 12 years of age will probably cost 50 cents per acre, with no income; the cutting or thinning after turpentining in the 8-inch class is expected to pay for itself through the production of one cord of pulpwood per acre. The final cut is expressed in board feet, Doyle scale, with full deduction for cull caused by turpentining. Utilization of the harvested trees for other products beside pulpwood and lumber might well occur but is not included here for the sake of simplicity.

Fire protection under the plan outlined is to be intensive, involving lookout towers, firebreaks, and organized personnel with equipment. It is assumed to be adequate to the extent of keeping at least 97 percent of the area free from uncontrolled fires, except for one serious conflagration such as may be expected in the pine belt on an average of once in 50 years. Losses due to this fire are included in the calculations of yield as running on from the middle of the rotation. Normal death of trees throughout the rotation has been taken into account in addition. Costs and returns for a 100,000-acre unit are shown below:

Average costs per acre per year:	
Protection and supervision	$0.14
Taxes	.20
Thinnings (every 8 years, at 50 cents)	.06
Total	.40
Average returns per acre per year:	
Naval stores rental from trees cut in thinning, 2 cents per cup	.41
Naval stores rental from trees of place, 4 cents per cup until trees become uniformly well spaced, then 5 cents per cup	2.54
Saw-timber stumpage	.48
Total	3.43
Net annual returns per acre (average over a period of 48 years)	3.03

The management outline given here is applicable to perhaps as much as 2 million acres of the better forest lands in the longleaf-slash pine type in northern Florida and southeastern Georgia, and elsewhere in the belt where forest conditions are similar.

MANAGEMENT PLANS WITH SPECIAL REFERENCE TO FUTURE EVEN-AGED STANDS

An owner of slash-longleaf pine land, who aims to obtain full production, will try to assemble approximately equal stocking of trees of different age classes, grouped in more or less even-aged tracts. He will endeavor as operations proceed to improve the stocking of his forest by planting, by purchase, of other stands, and by management which, generally speaking, will include the following activities:

(1) Survey and inventory.
(2) Control of fire throughout all stages of the operation.
(3) Thinning overstocked stands of young growth.
(4) Turpentining by conservative, sustained-yield methods.
(5) Utilization of turpentined trees for greatest profit.
(6) Restocking the land either naturally or by planting.

MANAGEMENT EXAMPLE 2

The basic information used for this example was obtained from surveys in Mississippi (*188*). The stand table and rate of growth are based upon the data obtained from the better classes of forest land, and particularly from second-growth stands which will adapt themselves readily to management. In the stand described there exists a preponderance of trees about 4 inches in diameter at breast height which are approaching the size for turpentining at an early date, say within about 15 years. Such stands have been available for purchase at about $5 an acre, which represents only a fraction of what it would cost to reproduce them. The following steps are postulated as a means for obtaining the greatest possible returns in the shortest time, and the income derived from each is given:

First year: At the time of purchase it will be necessary to thin the trees in the 2-, 4-, and 6-inch classes; under favorable conditions the cost of the thinning may be paid by the product	$0.00
Second year: It will be possible to cup 54 trees; the return will be a rental of 3 cents per tree for 7 years or $1.62 per acre per year	11.34
Ninth year: Forty-five trees will be back-cupped (54 minus mortality) at 3 cents per tree for 7 years, or $1.35 per year	9.45
Sixteenth year: The worked-out trees will be cut, producing 4 cords of pulpwood estimated at 50 cents per cord	2.00
It will be possible to cup 180 trees at 5 cents per tree for 7 years, or $9 per year (these are "trees of place")	63.00
Twenty-third year: One hundred and fifty-five trees will be back-cupped at 5 cents per tree for 7 years, or $7.75 per year	54.25
Thirtieth year: The worked-out trees will be cut, yielding 8,000 board feet, Doyle rule, at $4 per thousand or $32 per acre	32.00
It will be possible to cup 20 trees which have grown up from the smaller age classes to turpentine size and work them 7 years at 5 cents per tree, or $1 per year	7.00
Thirty-seventh year: Seventeen trees will be back-cupped at 5 cents per tree for 7 years, or 85 cents per year	5.95
By the forty-third year the remaining merchantable trees will be cut, yielding approximately 900 board feet, Doyle rule, valued at $4 per thousand	3.60
Total income for 42 years	188.59
Total cost at 40 cents per acre for 42 years	16.80
Average annual net income (over the period of 42 years)	4.09

The income of $4.09 obtained is much higher than the net income obtained in example 1 on page 98. This is because in example 2 the operation is started upon a more or less even-aged stand that has been already carried through the greater part of its nonproductive youthful period, whereas in example 1 the costs and returns are based upon the entire length of the rotation. The stand in example 2, after the steps just outlined, will continue to remain more or less even-aged and there will be a number of years after the forty-third year when operations must rest until the new stand reaches workable size.

It is believed that the costs and returns for both example 1 and example 2 are conservative and perhaps of more practical interest than that in example 3 which follows.

MANAGEMENT EXAMPLE 3

This illustration is based upon a method popular in forest economics of computing the productive value of the forest (*188*).

It is assumed that bare land is planted with slash pine, and that the plantation is managed for the highest financial returns for a period of 51 years. All of the costs and all of the returns are carried forward to the end of the rotation at a compound interest of 5 percent. The forest site is considered an average of the better class of forest land in the naval stores region. From increment studies made in natural stands and in plantations as old as 27 years, it is indicated that for open-grown planted slash pine, the trees will be 8 inches in diameter at breast height at 21 years of age, 11 inches at 29 years, and 17 inches at 51 years.

The slash pine trees are assumed to have been planted at about 350 to the acre. At the beginning of the twenty-first year, 200 are to be cupped, 1 cup per tree, for 8 years. After working, these 200 trees are removed from the stand. It is assumed that the cost of thinning is offset by the returns from the sale of the trees for pulpwood. At the beginning of the twenty-ninth year, the remaining 100 trees (allowing for mortality) are to be turpentined conservatively until the end of the fifty-first year at which time they are cut and the cycle repeated. The following is an estimate of the cost and returns from such an operation; which might vary appreciably depending on the quality of the site, the weather cycles, and the economics of the period covered:

Returns Per Acre

Turpentining rental, 200 cups (average 190 allowing for death of trees) at 3 cents, or $5.70 per year, twenty-first to twenty-eighth year, inclusive (rental paid at beginning of year) carried at compound interest of 5 percent to end of fifty-first year	$175.56
Thinning, stumpage	0.00
Turpentine rental, 100 cups (average 92) at 6 cents, or $5.52 from twenty-ninth to thirty-fifth year	103.01
Turpentine rental from thirty-seventh to forty-third year at $5.52 per acre	69.72
Turpentine rental from forty-fifth to fifty-first year at $5.52 per acre	47.19
Trees cut at end of fifty-first year yield 5,000 board feet, Doyle rule, at $4 per thousand	20.00
Total of the returns compounded to end of the fifty-first year	415.48

Costs Per Acre

Planting 350 trees per acre at $3 per acre, carried 51 years	$36.13
Administration and protection at 14 cents per year, carried 51 years	32.46
Taxes, 20 cents per acre per year, carried 51 years	46.38
Total of the costs compounded to the end of the fifty-first year	114.97
Total net returns $415.48–114.97=$300.51	
Average annual net return (this includes interest which amounts to about 70 cents a year if the land is figured at $3 an acre) over a period of 51 years	5.89

The annual net return per acre of $5.89 is much higher than in either of the two preceding examples. However, in this example it must be remembered that the owner actually obtains no income until the end of the rotation. At the beginning of the twenty-first year a large income is earned, but this income is carried at compound inter-

FIGURE 43.—A naturally reproduced stand of slash pine numbering 6,000 trees per acre at 8 years of age and in great need of thinning.

est to the end of the fifty-first year in order to compare the total final income with total final costs.

THINNING PINE STANDS

No feature of forest management, once a stand of timber is established and protected from fire, is of greater importance than the making of proper thinnings from time to time to produce the type of trees desired. The stunting, especially of crown and diameter growth, resulting from too dense stocking, produces a costly, persistent retardation of the development of the trees to a useful size (fig. 43).

Table 13 defines in number of trees per one-tenth acre the terms here applied to density of stocking.

TABLE 13.—*Terms used to describe degree of stocking in longleaf-slash pine stands* [1]

Range in average breast-height diameter (inches)	Classification of stocking by number of trees per one-tenth acre [2]				
	10	20	30	40	50 or more
0 to 2	Sparse	Sparse	Sparse	Sparse	Desirable to overdense.
3 to 5	do	Desirable	Desirable	Overdense	Overdense.
6 to 8	do	do	do	do	Do.
9 and up	Desirable	Overdense	Overdense	do	Do.

[1] From Southern Forest Experiment Station (*500*.)
[2] A circle with a radius of about 37 feet or a square 66 feet on each side has an area of one-tenth of an acre

NUMBER AND EXTENT OF THINNINGS

Considerable diversity of opinion exists as to when, and to how great an extent, stands should be thinned, but there is general agreement that thinning should be done gradually, if practicable under the limits of cost, so that the stands should suffer as little as possible either from continued crowding, or from being too open (*57*, *114*, *115*, *390*). Thinning should preferably not be done before the trees have attained a height sufficient to give them a fair chance of surviving accidental ground fires. Considering tree development and cost of thinning, as well as fire hazard in the turpentine belt, it is thought that slash pines about 15 to 25 feet in total height or with a range in diameter at breast height of 3 to 6 inches are best suited for a major thinning or stand-improvement treatment. Longleaf pines may safely be thinned when they are somewhat smaller, because they are less easily damaged by fire. In early heavy thinning in very young stands, made up of longleaf pines that have begun height growth but are less than 8 feet in height and slash pines less than 6 years old, there is a possibility of opening the stands to such an extent that a second filling in of the open spaces with a new crop of seedlings or undesirable undergrowth of gallberry, palmetto, or scrub oak may occur. Such a condition would entail an unnecessary cost for the removal of this new undesired crop unless the young seedlings die, as sometimes happens.

It is also important not to delay thinning too long, for the crowns of the trees may become so reduced that they are incapable of making a good response to the more open spacing created by the thinning. The cost of cutting larger trees, for example those 6 inches or larger in diameter 4½ feet above the ground (about 50 feet in height), is relatively great in proportion to the gain obtainable from increase in growth due to thinning the stand. Profitable improvement may sometimes be secured at this stage, however, if the trees removed can be marketed for pulpwood, poles, posts, and the like.

Close study of various methods of thinning is in progress on sample plots established by or in cooperation with the Forest Service, State forestry organizations, and also independently by private landowners (*57*, *114*, *408*, *409*). Thinning pine stands is already in practice commercially. It supplies useful work during winter and the improved growth in the thinned stands is readily seen and appreciated (fig. 44).

From the results thus far obtained from experimental thinnings in the South, and from those observed in French forests, the following procedure is outlined as being effective under the limits of present knowledge and utilization practices (*115*, *185*). The sequence to be followed does not involve all the steps practiced in France, but by reviewing these the procedure recommended is better understood.

The French procedure is indicated in figure 41. Repeated thinnings or cleanings of stands are made, often beginning when the saplings are only 5 or 6 years old, and being repeated at approximately 5-year intervals for 3 or 4 times (fig. 41, lots 1 to 4 or 5) before the trees are large enough for turpentining. This is considered profitable in France although without any considerable return from the material removed. Beginning even during this early

FIGURE 44.—A commercial thinning of a stand of 6-year-old slash pine trees about 4 inches in diameter and 15 feet in height with crowns 7 feet wide spaced approximately 12 by 12 feet apart or 300 to the acre.

period, and extending through the period of first working (25 to 40 years), which may be considered a second major division of the life history of the French stands, a selection of trees is carried on, the objective being the development of a stand of about 80 to 90 excellent trees per acre, evenly spaced, which are known as the "trees of place" or may be termed final crop trees. These trees are kept unworked during the second period of the operation of the forest, as illustrated approximately in figure 41 by lots 5 to 9 or 10. During this second period the trees to be removed are worked for turpentine, then cut, and sold for all purposes for which they are suited (vineyard stakes, mine props, pulpwood, fuel), thus bringing in a revenue while the selected trees of place are developing to a diameter of 12 or more inches. Then follows the third period, covering the repeated working of this selected stand (fig. 41, lots

10 to 14), which when turpentining is completed consists of trees large enough to produce saw timber (fig. 41, lot 15).

The application of the French management principles to slash- and longleaf-pine forests has additional advantages resulting from

FIGURE 45.—Experimental turpentine plot at Starke, Fla. *a*, Typical "tree of place"; *b*, representative tree of the type being turpentined prior to removal in the final thinning of the stand; *c*, piles of still wood obtained from thinnings.

the growth characteristics of these species, particularly slash pine, which on good sites promises often to attain turpentining size at an earlier age than the French maritime pine. Modification of French

methods seem probable in the United States, however, where, chiefly because of the costs involved, the thinning of stands may be concentrated in 1 or 2 operations and not extended over so many years as is the custom in France. Thus, between 5 and 20 years of age or as soon as the trees are about 2 inches in diameter at breast height, it may be found desirable to thin and perhaps even prune away the lower limbs till the stand has a stocking of 200, 250, or 300 trees per acre, that is, a spacing of about 15 by 15, 14 by 14, or 12 by 12 feet apart depending upon the judgment of the forest manager. Stands so stocked should then produce, without extreme coarseness of wood, workable trees of about 9 to 10 inches in diameter 4½ feet above the ground in a reasonably short time, say 15 to 30 years (fig. 41). Longleaf pines require more room to produce the same results than do slash pines but optimum stocking has not yet been definitely determined. From these 200 to 300 trees per acre, 80 to 100 or more evenly spaced trees would be selected and held unworked as indicated in example 3, page 101. On the other hand, the trees standing about these selected trees of place or final crop trees, would prior to their removal, be turpentined and utilized, during a period of about 5 to 15 years, to their utmost producing capacity for naval stores and wood products. This cutting would probably constitute the second and final thinning of the stand. It promises to more than pay for itself in the products obtained and at the same time would leave the selected stands of trees of place (fig. 45) with their potential qualifications for sustained gum yield and good-quality wood products (*476*).

SELECTION OF THE TREES IN THE FINAL CROP

In thinning densely stocked stands of longleaf and slash pine the trees left standing should be selected as well as possible for the following characteristics: The boles should be straight, clear of large limbs for at least one-third of their height, the tops should be unbroken and free from forks and from scars and other evidences of injury. The crowns should be full and thrifty, showing a good rate of growth, as indicated by the height growth made in each of the last few growing seasons. The trees should be selected from the largest, tallest, and best in the stand, and should be spaced as uniformly as possible. Table 14 indicates the approximate spacing desirable for stands of different average diameters.

TABLE 14.—*Desirable spacing for young longleaf-slash pine stands* [1]

Diameter breast high (inches)	Approximate distance between trees	Trees per one-tenth acre [2]
	Feet	
3 to 5	12	30
6 to 8	15	20
9 and up	21	10

[1] From Southern Forest Experiment Station (*500*).
[2] A circle with a radius of about 37 feet or a square 66 feet on each side has an area of one-tenth of an acre.

The average distance from a selected tree to its three nearest neighbors should be considered as the measure of spacing. Exact spacing in natural stands is usually impossible in practice where the governing principle is to leave as nearly as possible the desired number of trees per acre so situated that each tree has room to develop properly.

When the final-crop trees have been selected, the trees about them are cut, except perhaps seedlings below waist height. There is a tendency to leave more trees per acre than is intended so that frequent checks on results being obtained should be made.

COST OF THINNING

On the Osceola National Forest in northern Florida improvement cuttings in young stands having 400 to 1,200 trees per acre have recently been made. The trees removed averaged 2½ inches in diameter at breast height. Trees more than 6 inches in diameter were not cut. The operation was designed to reduce stands to approximately 200 trees per acre more or less evenly spaced. In such a case the trees to be cut could be marked by skilled men at a cost of 25 cents per acre (*408*, *409*). The cost of cutting by unskilled labor, paid at the rate of $1 per 8-hour day would average as follows:

Trees cut per acre	Labor cost for cutting alone
Number	*Cents*
200	10
400	17
600	28
800	43
1,000	68

Costs for similar work obtained from other holdings has averaged 20 to 35 cents per acre.

If economic conditions should change, particularly if smaller trees could be marketed at a profit, the plan of thinning would also change. For instance, if trees about 6 inches in diameter at breast height could be marketed at a profit, either before or after working, the number to grow, up to the time of first profitable thinning, might be more than 200 or 300 per acre.

TURPENTINING UNDER A MANAGEMENT PLAN FOR SUSTAINED YIELD

The first and greatest revenue from young slash and longleaf pine stands comes from the production of gum from the living trees. This product moreover promises to continue to be of major importance and high relative value in the future profitable use of the land in the region where these trees grow (*94*, *275*). The trees may be worked by the owner, or he may lease the turpentine rights to his trees to someone who is willing to work them for him in return for a share of the products, or who will buy the lease outright (p. 37).

At least two types of operation can be used for obtaining naval stores on a sustained yield basis. In the first all trees would be turpentined as soon as they were large enough, about as indicated in example 1, page 98. The trees would be turpentined for 1 to 3 workings and then would be cut when their full yield of gum had been obtained (*184*). Smaller trees would be expected to replace them. In some existing stands this procedure may serve a useful purpose, and it also insures the earliest income, but the French found that it did not give so high returns as the second method next described. The value of the timber moreover is usually also sacrificed to some extent under the foregoing plan of operation. The French therefore discarded the procedure and there is no apparent reason to expect that results would be different in the future in the slash and longleaf pine forests of the United States.

According to the second plan of operation the first working of the stand would include the obtaining of gum from part of the trees making up the 200- to 300-tree-per-acre stands, but this would not include the selected 80 to 100 or more trees per acre termed the trees of place or final-crop trees. The trees first turpentined would include some that would be relatively small or undesirable. The working would probably range over a period from the time when the trees were about 15 to 20 or more years of age until the time when they were 25 to 30 or more years of age. The gum from these trees would be obtained by working them to their fullest capacity, even to the point of crippling their growth, although using care in the operating methods in order to maintain their good health sufficiently to keep their gum-yielding power at as near a maximum as possible. This working would correspond to the heavy chipping used in India (p. 162), and the "turpentining to death", gemmage à mort, used in France (p. 148). It would probably cover a relatively short period, 3 to 10 years, according to economic conditions and the desirability for hastening or delaying the second period of operation, namely, the working of the trees of place, the growth of which will be somewhat retarded as long as the other trees remain to occupy space and draw their share of moisture and nutriment from the soil. At the end of the first working or of a second working, all the turpentined trees would be cut and removed, leaving a stand made up of the selected trees of place ready for the principal step in the operation of naval stores production. It is assumed that the gum and the wood products (stave bolts, pulpwood, railway ties, and still wood) obtained from the trees first worked will cover the cost of their removal to improve the stand, and if conditions are favorable will produce some profits.

The second and major step in the production of naval stores is the conservative and continued working of crops made up of the stands of the trees of place which then enjoy opportunity for optimum growth. Such working may extend over a considerable period of years, for example, for 21 to 40 or more. It may include the chipping of 2 or 3 single faces in succession on each tree (fig. 46) with the expectation of a high and continuous yield of naval stores.

The trees of place will at the beginning of their naval-stores-yielding period have attained at least 10 or 12 inches in diameter at breast height, will have well-developed crowns, and will be openly spaced,

that is, 20 to 30 feet apart. Rest periods of from 1 to 5 years will probably be found desirable and generally should be allowed between the working of successive faces in order to permit the recovery of the tree from the drain of turpentining and to allow time for the healing over of the worked face and the natural increase in circumference, which will increase the working area available (fig. 46).

The rate of healing over of the worked faces is an important factor in plans for the successive working of pine stands for naval stores production. In the past relatively little attention was given to this point since it was the general practice to work only the large virgin trees just before they were to be cut for saw logs. With the present and future use of young trees, however, the width of the first face and the later faces as well as the speed of healing and the increase in circumference which may be expected from ordinary growth are significant elements in drawing up management plans for pine timberlands (*191*, *386*).

In France (p. 152), for example, the narrow faces often heal over completely and new faces are later placed on the surface directly

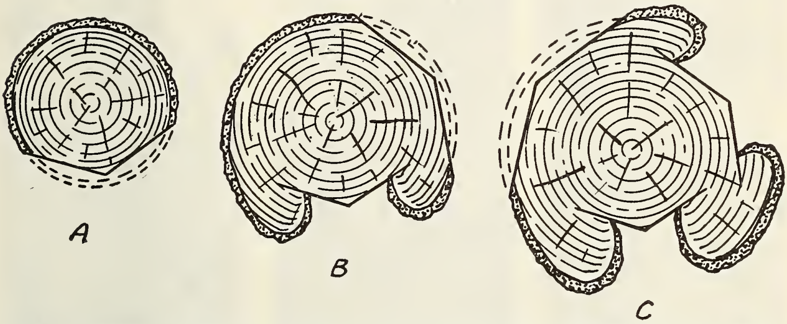

FIGURE 46.—Three successive workings of a slash pine tree: *A*, First working when 10 inches or more in diameter at breast height; *B*, second working about 6 years later; *C*, third working, the tree meanwhile having continued its growth.

over the old ones. This practice is rare in the United States although highly productive faces are often cut on the rolls of healing wood tissue that grow in from the sides or shoulders of the chipped faces (fig. 47, *C*). The rapid growth and healing of vigorous young pines has often in recent years made possible three workings of relatively young trees (fig. 42). The typical wide American faces have not generally had an opportunity to heal completely, due to subsequent damage from fire or other circumstances resulting from the heavy chipping practiced in the past, but a few instances are on record (fig. 47, *B*) of practically complete healing in the course of 12 to 15 years. The rate of healing is determined by the growing power of the tree and its capacity to form new woody tissue at the sides of the faces (fig. 47, *A*).

The best opportunity for healing appears to be offered by the French type of face with the rounded top and no peak. The use of two French faces with a 4-inch bar of bark between (pl. 4) presents, although not yet fully tested, one of the most promising possibilities for application in stands of vigorous timber designed for 2 or 3 successive workings.

When after successive workings it is no longer profitable to turpentine the trees of place, they can be felled as is indicated in figure 41, lot 15, and, if low chipping (p. 62) has been practiced, only 4 to 8 feet of the butts will have been scarred by three or more successive workings of from 5 to 8 years of chipping so that the wood products also from these trees should net a profitable return.

A third but relatively untried procedure involves holding the trees of place unworked until the size desired for saw timber is practically attained. Then by the use of intensive and very frequent chipping, exceedingly high yields might be obtained in 1 to 3 years with a minimum of damage to the timber or hazard from fire. The total gum yield under such procedure, however, would probably not equal that from the more lengthy working.

FIGURE 47.—*A*, Vigorous open-standing young tree showing how the first-year face may be almost completely healed before the last is finished; *B*, larger tree growing in the open, the wide face was completely healed in less than 12 years; *C*, although this boxed tree was severely burned a productive face was placed so that a large share of the yield came from the healing tissue above the old scar.

YIELD OF OTHER PRODUCTS UNDER A MANAGEMENT PLAN FOR SUSTAINED YIELD

Slash and longleaf pines are often described as multiproduct trees because, in addition to the abundant yield of gum that can be obtained from them, they also produce pulpwood, saw timber, poles and piling, railroad ties, stave bolts, and fuel. In the managed forests of France, naval stores and wood products rank as of about equal value; in India naval stores yield a higher monetary return than wood products, whereas in the days of the virgin forest in the United States the wood products outranked naval stores in importance (*227*). It seems probable that in the future conditions in the United States may more nearly approximate those in France, since the production of naval stores is not incompatible with the production of a variety of wood products when the stands are properly managed (*559*).

THE INFLUENCE OF GROWTH CONDITIONS

Both slash and longleaf pines are capable of producing wood of greatly varying density (pl. 10). The type of tree and of wood produced (pl. 10) is influenced markedly by the type of stand in which the tree grows (*415*, *416*, *418*). The wood from the fastest-growing, high-gum-yielding trees with large crowns tends to be less dense than that produced from slow-growing trees, but the lighter wood is suited for certain uses where strength is not of primary importance. To meet the requirements for strong, dense southern pine for construction purposes, however, each annual ring must contain not less than one-third summer wood, and there must be six or more annual rings per inch (*159*, *501*). Such dense wood with narrow annual rings can be produced in closely stocked second-growth stands as well as in virgin stands, but its production lengthens the time required to produce trees of a given diameter and hence tends to reduce the yield of gum obtained from each tree during a given period of years.

Controlling the spacing of trees in a stand by planting or thinning is a potent means for producing the type of tree desired and of reducing or prolonging the period required for it. Other factors, such as soil and moisture, however, are also active. Experiments indicate that the amount of summer wood formed is dependent on the length of time in the growing season that sufficient soil moisture is available (*423*). Even in crowded stands trees growing on good sites may produce wood of high density, but very heavy wood may also be produced in open stands where soil and moisture conditions are optimum. It is evident therefore that understanding the relation of the growth conditions is a decided advantage in determining the type of trees to be grown (*420*). The type of growth of trees on old fields is for example strikingly different, especially during early years, from that of typical forest-grown trees.

Pruning, which is used commercially in other parts of the country, may also be used in future in southern pine plantations or stands as a means of increasing profits (*419*) where trees are too widely spaced to prune themselves naturally.

EVALUATING GROWING STANDS

All slash and longleaf pine trees will not grow so fast as the records indicate in cases of maximum development on especially favored sites (*69*). It is therefore desirable to be able to evaluate stands that are to be purchased or to check expectations against actual growth obtained in managed stands. This can be done in a number of ways (*241*, *526*). The first simple and somewhat rough method is by the inspection of external characteristics.

Obtaining an average measurement for the height of a number of the tallest or dominant trees in a stand of a given age, such for example as 50 years, is known as a reliable and convenient means for determining the site classification or producing capacity of forest land. So many determinations of this character have been made that standard curves are available for such species as slash and longleaf pines (figs. 48 and 49). These record the average

heights found on a variety of soils at given ages and, by comparing these data with those obtained from the trees being examined, the

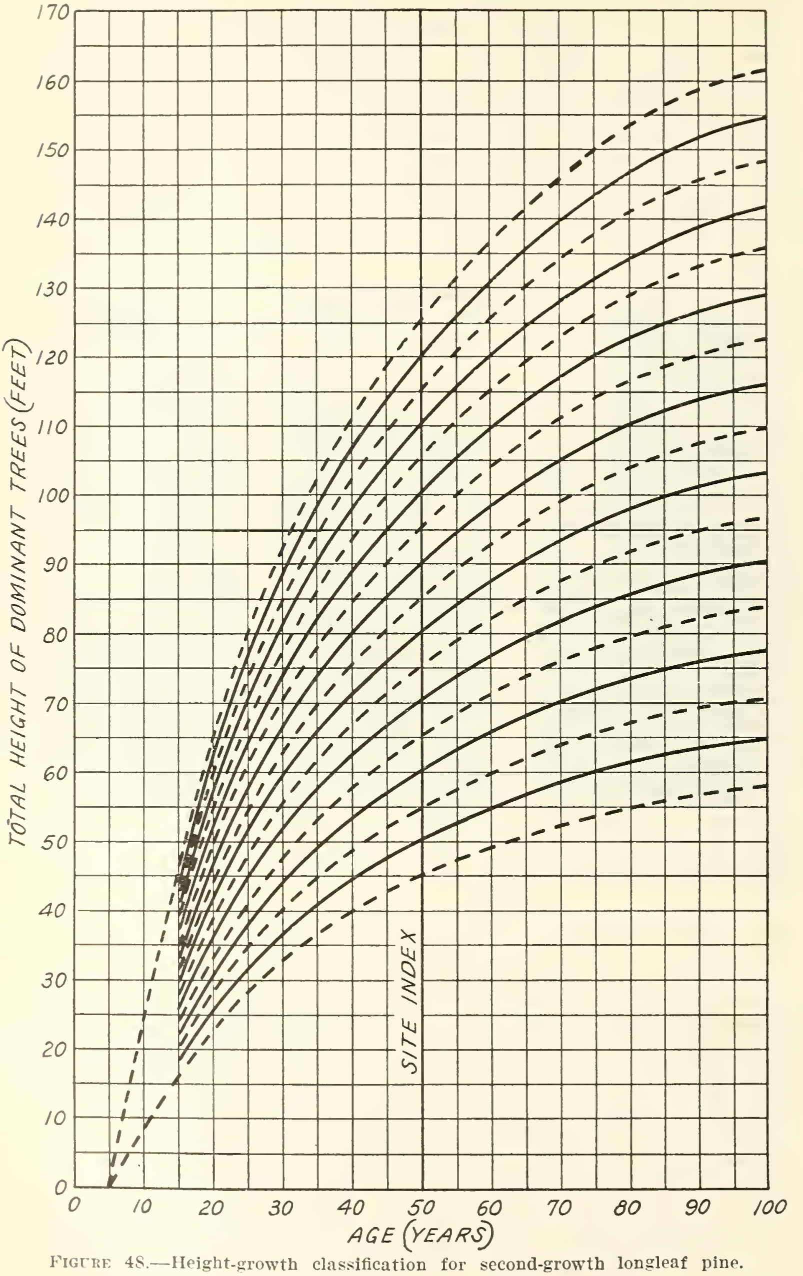

FIGURE 48.—Height-growth classification for second-growth longleaf pine.

relative producing power of any given tract can be estimated (*530*). Another method also used by foresters is the calculating of the

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EXTREME VARIATIONS IN THE RATE OF GROWTH AND DENSITY OF THE WOOD OF SOUTHERN PINES ARE SHOWN BY THE ABOVE DISKS.

The rate of growth and quality of wood may be controlled to a large extent by the proper spacing of the trees.

basal area of the stand.[22] A dense stand, for example, made up of small trees may have a smaller basal area and less useful and less valuable trees than a well-stocked stand containing only 25 percent as many trees (*74*). Boring into a tree with a hollow auger, or increment borer, is also helpful in determining the rate of wood formation.

Still another method used is to determine growth responses in trees by examining the annual rings at different heights in typical felled trees. The method is known as stem analysis (*73*, *119*, *430*).

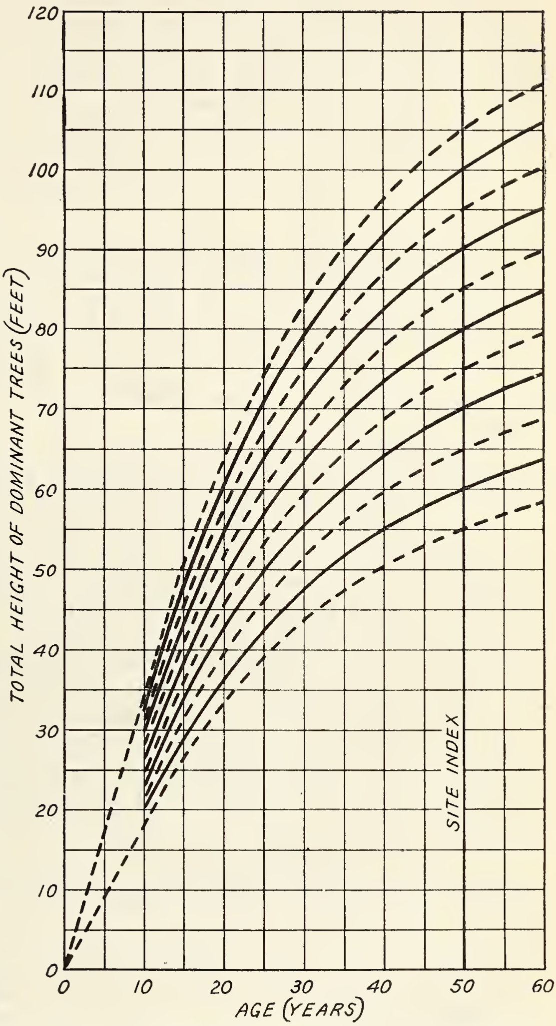

FIGURE 49.—Height-growth classification for second-growth slash pine.

PULPWOOD

The successful and increasing production of pulp from southern pines (*154*) has introduced the possibility of growing forest crops so that they will meet the requirements of both the pulp and paper and the naval-stores industries as well as producing a good percentage of each crop in the form of saw logs (p. 115). The average growth of the forest stands in this region (p. 111) has resulted in yields of 21 cords of rough wood per acre from 25-year-old stands of longleaf pine and 42 cords per acre from slash pine of the same age showing slash and longleaf pine to be excellent sources of pulpwood (*421*, *422*, *530*). Optimum yields from longleaf pine and slash pine at 25 years of age are 44 cords and 60 cords per acre, respectively (*101*, *102*, *105*, *456*, *457*, *458*). In stands managed for a variety of products perhaps only about one-half of the preceding pulpwood yields could be removed from fully stocked stands in

[22] The basal area is the number of square feet in cross sections at breast height of all the trees standing on an acre.

which thinning has been delayed until the trees had reached sizes suitable for turpentining.

In the United States pulpwood from trees 8 to 15 inches in diameter at 4½ feet above the ground is preferred but trees as small as 6 inches with a top diameter of only 3 inches are used. The handling of the small material costs more proportionally and there is more waste in cutting and stacking it. It is estimated that 10-inch trees contain four times as much wood as 6-inch trees and that it only costs twice as much to handle them (*115*). However, if the removal of the wood has served to improve the stand from which it was cut it may be possible to adjust costs so as to make the taking of this material also present some advantages to the pulp producer.

Owners of young stands, however, should realize that increased profits can probably be obtained by utilizing their longleaf and slash pine stands for a variety of products and not clean cutting them as soon as they reach the minimum size acceptable for pulpwood (*11*). Moreover, it should be realized that even with a greatly increased pulp production in the South only a relatively small proportion of the pine trees that can be grown could probably be utilized for pulpwood, and therefore a diversity of products rather than one commodity alone should be the objective of owners of forest land.

The fact that sapling pines, such as are removed in improvement thinnings for naval stores and timber production, contain little or no heartwood (fig. 12) (*289*, *290*, *422*, *474*) and have a comparatively low resin content (*277*, *334*, *402*) has caused the making of sulphite and ground-wood pulps from slash and longleaf pines to be investigated. These pulps are the basis of standard newsprint paper and other paper products of large tonnage, at present made almost entirely from northern conifers. Excellent papers, including newsprint, book, bond, and similar grades, have been made from sulphite and ground-wood pulps prepared from these woods at the Forest Products Laboratory (*45*, *46*). Similar results have been obtained by the Georgia Paper Laboratory in Savannah (*369*). Strong white papers have also been made at the Forest Products Laboratory from slash pine and from longleaf pine by the sulphate process where the resin contained in the wood does not interfere with pulping as any considerable percentage of it does in the sulphite process. The manufacture of white paper makes possible a diversification of the product manufactured by pulp mills already located in the South. The fact that the young black gum, often found on turpentine tracts, may be made into white pulp that combines well with the pine pulp is also of significance in forest-management plans for the southern pine region (*155*).

POLES AND PILING

The requirements for poles and piling are also readily met by young slash and longleaf pines that are grown with not very wide spacing. The size required for poles and piling is 10 inches and over at breast height. Heavy crook and excessive knots are not allowed in this material. According to standard pole specifications no pole should have a turpentine face or other scars located within 2 feet of the ground level (*31*). The distance from the butt to the

ground line may vary from 3½ to 11 feet. Therefore, this requirement gives an added incentive to the use of low faces. The fact that a considerable part of the tree is sapwood is of advantage if the wood is to be given a preservative treatment since sapwood is more easily penetrated with wood preservatives than heartwood.

A dense stocking on good soil up to an age of 20 to 25 years, or on poor soil to 30 to 35 years, is considered desirable for producing poles and piling. Such growth conditions will produce tree stems fairly free of branches and with no large knots to a height of more than 30 feet. Such trees will more nearly approach the form and structure of virgin stands than trees which grew more widely spaced during their early years.

RAILWAY TIES

Throughout the rotations of the pine forest crop scattered trees which die or which for any reason it is desirable to remove, are often cut into railroad ties. The tie industry is therefore a source of revenue and employment not to be ignored in the complete utilization of the forest stand.

SAW LOGS

Properly safeguarded by the use of conservative chipping methods, the turpentining of slash and longleaf pine trees need not reduce the yield and value of the wood products to an unreasonable extent (*187*). When young trees are turpentined for three successive workings, however, the butts will not be suitable for saw lumber. But the turpentine faces need not extend more than 5 or 6 feet above the ground even if worked for 5 years each, and this portion can be trimmed off for fuel or other use, leaving a good clear length of unscarred bole for lumber. The number of trees which die as a direct result of turpentining by modern methods under normal environmental conditions has been found to be very low, often not more than 0.5 percent annually (*571*).

A study made of virgin pine which had been turpentined carefully by the cup method just before it was cut showed that no loss or damage was caused by the turpentining, the scarred surfaces being entirely trimmed off with the first slabs cut. Such working is not to be confused with the earlier, more destructive effects produced when the cutting of deep boxes in the tree butts was the general practice and was followed by wholesale fire, insect, fungus, and wind damage (*202*).

An investigation of the effect of turpentining on the strength of the worked virgin timber showed that the turpentined timber was as strong as the unturpentined timber originally of the same density, and that the turpentined trees contained practically neither more nor less resin than those not chipped (*402*, *433*). In other words, no loss in resin occurs in the heartwood. Any change in resin content that exists is confined to the sapwood which sometimes, when deep chipping is used, becomes pitch-soaked, that is, contains more resin than normal.

Under the lumber grading rules of the Southern Pine Association (*77*, *501*) pitch is held to be a defect in some grades of flooring if in the form of " pitch pockets bleeding one-eighth inch in width ", but " pitch is permissible, if not in excess of one-fourth of the area

of the board." It should be remembered that pitch pockets and pitch soaking also may occur quite independently of the working of the tree for turpentine.

FUEL WOOD

A necessary though often not very remunerative use of slash and longleaf pine is for fuel wood. The turpentine still and the dwellings occupied by the woods workers are constant users of wood fuel, and if a town or village is near the woods, markets for fuel wood may also be developed, although the wood from saplings finds small favor where lightwood from pine knots, old stumps, or turpentine faces may be had.

MISCELLANEOUS

Numerous special uses, such as the production of wooden staves, conduit pipe, and box material are also developed locally.

The logs cut from the second-growth stands which are furnishing and will in future furnish lumber, contain far less heartwood than has been found in the material from the virgin stands. This sapwood lumber, though it tends to have wider growth rings, more soft-textured spring wood, and more knots than the products of the virgin timber nevertheless has certain inherent advantages. The sapwood of these pines seasons more easily, for moisture moves through it much more readily than it does through heartwood. Moreover, it is treated more readily with preservatives and fire-retardant mixtures, and makes stronger glued joints and retains paint better than the denser virgin-grown material with a high percentage of summer wood.

RESTOCKING LAND FOR NEW FOREST CROPS

When farm lands are to be converted into forests or when bare or cut-over areas require restocking, new stands of slash and longleaf pine trees can be obtained (1) by planting of wild or nursery-grown seedlings (fig. 50, *B*) rather than by sowing seed, (2) by natural reseeding from seed trees present or left for the purpose (fig. 50, *A*), (3) by the development where present of suitable advance growth of young trees that survived the cutting out of the old stand, a comparatively rare condition except where selection logging is practiced, or (4) by a combination of these means (*100*, *103*, *215*, *216*, *217*).

SEED TREES

Leaving seed trees until a well-established restocking has taken place is a very practicable but not always the quickest means of reforestation. Even a good stand of advance growth or a plantation may be wiped out by a single fire while the seedlings or saplings are still small, but this usually would not kill trees of seed-tree size. An ideal seed tree for the naval-stores region may be described as a healthy, preferably unturpentined, slash or longleaf pine having a long vigorous crown (*201*, *221*, *433*, *544*) with a pointed, not flattened top and abundant foliage. The diameter at breast height should not be less than 10 inches. Trees that have grown in openings are also preferable since they are usually braced better against windfall than trees that have been crowded during their growth in groups

with other trees. If seed trees can be selected during heavy seed-producing years a better idea of their capabilities can be obtained than otherwise.

The relation between diameter and seed production in longleaf pine is shown in table 15. Four or more seed trees per acre should be

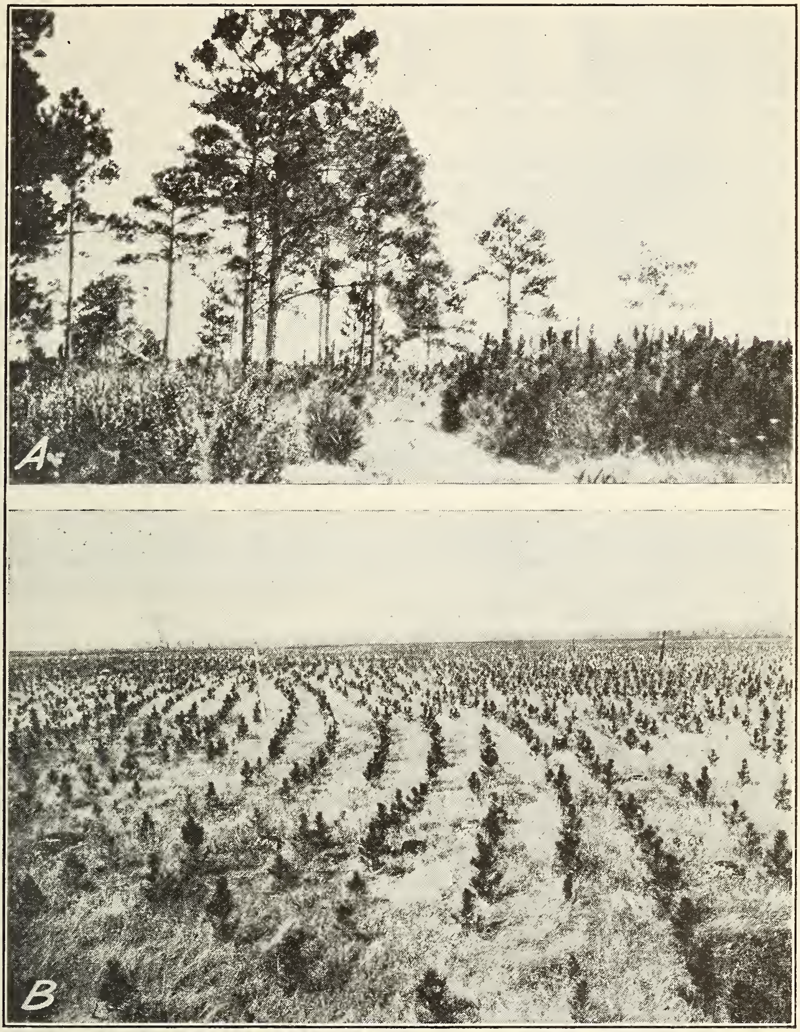

FIGURE 50.—*A*, Vigorous slash pine seed trees have caused a dense stocking of new growth all about them. *B*, Commercial plantation of slash pine in Louisiana which has been planted 3 years. The trees are 4 years old, having been transplanted after 1 year's growth in a nursery. They are spaced 6 by 8 feet apart or about 900 trees to the acre.

left, but no inflexible rule as to the number of seed trees required per unit area to give a good restocking can be drawn since the character of the surrounding lands, which may also be stocked with abundant seed trees, will exert a decided influence on conditions in small areas or on the edges of large tracts.

TABLE 15.—*The relation of diameter to abundance of seed production in 596 longleaf pines growing on cut-over virgin pine lands in southern Mississippi* [1]

Diameter class (inches)	All trees	Abundant seeders		Diameter class (inches)	All trees	Abundant seeders	
	Number	*Number*	*Percent*		*Number*	*Number*	*Percent*
6	97	6	6	14	50	39	78
8	91	20	22	16	23	21	91
10	167	91	54	18	12	10	83
12	156	105	67				

[1] Data from U.S. Dept. Agr. Tech. Bull. 204 (*201*).

The chief disadvantage of depending on seed trees for restocking is that in some situations adequate restocking may be slow, especially in the case of longleaf pine, and the distribution of young trees irregular and unsatisfactory because of interference by such natural conditions as matted grass or dry surface soil so that the greatly-to-be-desired, fully stocked, even-aged stands will not result (*75*). Under other conditions and especially with slash pine, very abundant and satisfactory restocking may be obtained at no cost except that of protecting the area from fire.

Adequate information on the relative value of seed as obtained from different trees is not available. It is customary, however, not to select for seed or seed trees inferior, poorly developed, or spiral-grained trees. Studies made in India on the effect of selecting seed from pine trees with spiral grain have indicated that a considerable proportion of the seedlings reproduce this defect (*122*, *123*, *124*, *125*, *126*, *127*). It seems probable that with increasing knowledge about plant breeding the choice of seed trees and of seed for raising nursery stock will become more exacting.

COLLECTION AND CLEANING OF SEED

It is essential that the pine seed used shall be fresh (p. 11). It is most economically obtained from the cones on trees recently felled in logging (*16*). Cones must be gathered in early autumn when the seed is mature but before the cones have opened to allow the seeds to fall out. Closed cones if spread in a warm dry place will open and shed their seed. Extraction of seed is sometimes hastened by drying cones for 12 to 16 hours in a lumber dry kiln at 20 percent relative humidity and temperatures not in excess of 120° F.

A bushel of sound ripe cones usually yields about a pound of seed. The wings on slash pine seeds are often removed by spreading the seeds in a layer 1 inch deep on a screen-wire tray, sprinkling them with water till thoroughly moist, stirring vigorously for 10 minutes, spreading again in a thin layer, then placing the tray in the sun and stirring the seeds vigorously once an hour till they are dry. Removing the wings is also done by rubbing the seeds between the hands and winnowing them in the wind or before an electric fan. It is not customary to remove the wing from longleaf pine seeds, since it does not readily separate from the seed as does the wing of slash pine seeds.

PURCHASING SEED

Both seed and planting stocks of slash and longleaf pines may be purchased.[23] More favorable terms can usually be obtained on stock ordered in large quantities or contracted for a year or more in advance.

DIRECT SEEDING

Gathering seed and sowing it broadcast on the land is a cheap method of planting sometimes used but the results, except in some cases of slash pine seed sown (1 to 2 pounds per acre) on wet land, have been unsatisfactory. Usually a large proportion of the seeds are eaten by birds or rodents. Moreover, the seeds thus sown do not germinate satisfactorily or if they germinate suffer from extremes of temperature or moisture. Even if the seeds grow into seedlings the young trees are not all well spaced and generally are not so sturdy and do not have so well-developed roots as seedlings grown in protected seed beds in the simple nurseries such as may be established by anyone (*547*). Even properly transplanted wild stocks of thrifty seedlings, if dug up when 8 months to 1 year old have frequently been used with greater success than is obtained from scattering seed. Dropping seeds in spots or furrows and then working them very lightly into the soil with a rake or tramping them in is sometimes practiced. One method used has been to drop about 8 seeds at intervals of 6 to 8 feet in furrows spaced 8 to 10 feet apart, giving roughly about 700 spots per acre.

As a general rule, it is advisable to use species and seed that are native to the locality and known to be capable of growing under the conditions existing in the area to be planted (*532*).

PRODUCTION AND USE OF SEEDLINGS

When land has been clear cut, leaving no seed trees, or burned so that no reproduction remains, artificial reforestation by planting is needed. In this way a regularly spaced, fully stocked, even-aged stand may be obtained. It is necessary that the seedlings become well established and be fully protected from fire damage (fig. 50, *B*). In such stands the cost of thinning to obtain the uniform spacing required in natural regeneration is saved because of the regular spacing of the planted trees which also favors their early all-round development. Later thinning as required, however, would be made (p. 101). It is thought that proper planting will reduce the time required to produce pulpwood by from 3 to 5 years, and that required for saw-log production by from 5 to 10 years (*115*) and at the same time it will considerably increase the volume of the crop.

Farmers, small turpentine operators, schools, or clubs are as well situated as large landowners for establishing seed beds in which planting stock can be raised (*578*). A seed bed should be located on level ground and the soil should preferably be somewhat acid and as free as possible from weed seeds. The soil should be well spaded, pulverized, and raked smooth. Old garden soil may be alkaline

[23] A list of dealers who are usually prepared to supply pine seed and small trees and who will quote prices on request, can be obtained on application to the Forest Service.

or neutral and often is infected with the damping-off fungus (p. 141), which kills young seedlings.

A useful size for a seed bed is 4 by 12 feet. Such a seed bed has a capacity of more than a thousand seedlings. It is well to prepare the seed bed about 1 month or more before sowing the seed. After the soil has settled it is freshly raked and leveled before the seed is sown.

Early spring is generally a more satisfactory time than autum for planting the seed in beds. The seed is broadcast evenly or sown in drills about 6 inches apart in the bed. It is then rolled or pressed into the soil and covered to a depth of not more than one-eighth inch with soil or with a single layer of burlap sacking instead of soil. The bed is then kept watered during dry periods and the burlap removed as soon as germination begins.

Not all the seeds in a bed will germinate, but a stand of 30 or 40 longleaf seedlings to the square foot, or of 10 to a linear foot of drill, is desirable (*59*). Slash-pine seedlings, which are smaller than those of longleaf, should number 40 to 50 per square foot or 12 to 15 per foot of drill. If a larger number develop the beds should be thinned when the seedlings are about 6 weeks old in order to approximate the foregoing stocking, otherwise growth is likely to be unduly retarded. It is quicker and safer to cut seedlings off with scissors than to pull them. Weeds, however, should be pulled from the seed beds as soon as they develop (*541*). The seed beds require plenty of water and should be sprinkled frequently during dry periods. Where water is scarce or not available, it is well during the first 3 or 4 months of growth to shade the young plants by removable frames made of strips of lath set to run north and south. The lath are usually nailed 1 or 2 inches apart, and are supported about 1½ feet above the bed. The frames are set aside in wet, cloudy weather.

It is desirable in the tracts to be stocked to plant the seedlings from the nursery between the time in the autumn when the year's growth is over and the time in spring when the buds begin to swell, that is roughly, although there is much local and annual variation, some time between December and February. The species planted should be selected with reference to its adaptability to local conditions.

The land may be prepared for planting slash pines by plowing shallow furrows that may be, according to the planting plan used, from 6 to 12 feet apart. The upturned earth tends during the first year after planting to protect the seedlings from fire. Either a middle breaker or a turning plow can be used.

The tools generally used for planting are a planting bar, mattock or grubbing hoe, and a spade. In more open soil the planting bar, a tool with a wedge-shaped blade 3¼ inches wide and 9 or 10 inches long welded to a ⅞-inch bar, gives practical service. In using a planting bar two men constitute a planting crew. The first man makes a straight downward stroke with the bar, producing a slit in the middle of the furrow and crosswise to it (fig. 51, *A*, *B*). The second man inserts the seedling and the first man closes the bottom of the slit by driving the bar in on a slant about 4 inches away from the seedling and prying down (not up) on the

handle (fig. 51, *C*, *D*). The top of the slit is closed by a slight upward motion of the bar, followed by a thrust from the planter's heel (fig. 51, *E*). It is important that the man with the planting bar open the first slit with a straight downward stroke and not by pushing the bar handle back and forth which makes the bottom of the slit so large that it cannot be closed well. When the slit is not well closed the seedling is likely to dry out and die. Much care is needed to close the entire hole tightly as shown in figure 51, *E*. In easily worked soil a two-man crew can plant about 2,000 trees a day. Pine plantations are considered successful if 70 percent or more of the trees live through the first year after planting (*278*, *382*, *383*, *542*, *543*).

Particular attention should be given to the following points of procedure in planting (*141*, *389*, *477*, *543*).

Seedlings should be carefully lifted from the seed bed or other place where they are growing so as not to break the fine rootlets.

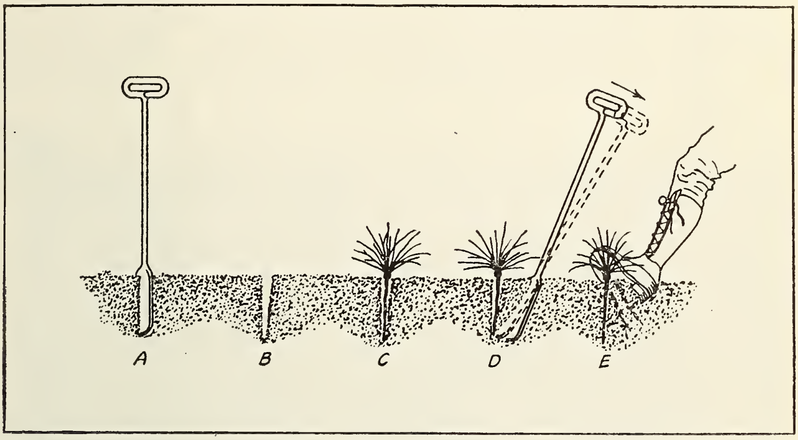

FIGURE 51.—Planting pine seedlings with a planting bar as planting tool: *A*, Insert planting bar vertically into the ground the length of the blade; *B*, withdraw bar from slit; *C*, insert small tree carefully with root straight in slit; *D*, insert bar, pressing soil against root by movement shown by arrow; *E*, complete the planting by forcing the surface soil with the heel of the shoe.

They may then be tied in bundles of 50 or 100 and packed at once in wet moss or burlap or placed in tubs or buckets containing water in which they can be carried to the planting site. If not desired till the next day, the roots but not the tops, should be put into a shallow trench and covered with earth in some cool shaded place where the soil is moist.

During planting the roots must at all times be kept wet as even slight drying may ruin the seedlings.

Slash pine seedlings should be planted at the same depth or only a little deeper than they grew; the roots should be spread out, not bunched. Longleaf pine seedlings should be planted a half inch higher than they grew in the seed bed and care should be taken to provide against the washing in of the soil which otherwise might cover the terminal bud and smother the plant; longleaf seedlings should be planted without furrowing.

The soil should be made firm about the plant. This may be done with the heel of the shoe. This helps prevent undue drying out. Straw or loose soil on top of the firm soil surface may also be used to act as a mulch.

Cloudy weather following or preceding rain is most desirable for planting.

Young plantations should be protected completely from fire and hogs. One hog can destroy 10 or 15 acres of longleaf plantation in a month and even slash pine is not entirely immune (p. 132). In large plantations fire lines should be constructed around every 40 acres.

FIRE, GRAZING, INSECTS, FUNGI, AND OTHER FACTORS AFFECTING FOREST PRODUCTION [24]

FIRE

No general statement on forest fire can be made that is uniformly applicable to all parts of the southern-pine region. The solution of the fire problem and the desirability of using fire for specific forest-management purposes will differ with individual tracts and will vary with tree species, size of trees, density of stand, quantity of combustible material present, weather, and other factors. No single set of recommendations can fit all conditions. Where forestry is to be successfully practiced, however, uncontrolled fire cannot be tolerated.[25]

The protection of pine seedlings from fire during their earliest development is, generally speaking, essential. That longleaf pine seedlings frequently survive repeated burning during their early years does not alter this fact (*36*, *186*, *357*). Very young slash pines require absolute fire protection if they are to survive. The relation of fire, especially light-grass fires burning during winter, to the control of the brown-spot needle disease which often severely attacks longleaf pine seedlings during their early years while the foliage is within about 18 inches of the ground, is a subject which has drawn attention to the possible usefulness of controlled fire in checking the disease (p. 142). The evidence, however, indicates that the beneficial effects of a fire may vary somewhat with local conditions, and that fire may often do as much harm as good to the young trees.

The cut-over pinelands, bare of young trees, which are so widespread throughout the southern pine belt, clearly attest the power of uncontrolled fire combined with other influences such as clear cutting and hog pasturing as agencies which are very effective in keeping land permanently unproductive or, at best, in greatly delaying its adequate restocking (fig. 52).

After a stand is well established, however, and has attained the sapling or a larger stage, the effect of fire may vary greatly according

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[24] Compiled by Eloise Gerry chiefly from information furnished by the Forest Service, Bureau of Entomology and Plant Quarantine, and Bureau of Plant Industry.

[25] DEMMON, E. L., FIRE IN THE SOUTHERN PINE FORESTS, June 21, 1932; South. Forest Exp. Sta. [Mimeographed.] Also (*529*).

to conditions and the season at which it occurs (*47*, *87*, *118*, *135*, *165*, *308*). In winter the buds of the trees are dormant and in longleaf pine they are so effectively protected that trees survive fire of a severity that would kill them if it burned in the summertime. Humidity and wind velocity are factors that greatly influence the behavior of fire and its effects. The volume of inflammable material lying or standing on the ground is a varying and a powerful factor as well. In periods of drought, fire does far more damage than at normal times.

Because they so often survive and put out new foliage the actual damage done to growing pine trees by fire is very often not realized. It is, however, recorded in the width of the annual rings and in height growth. Young longleaf pine, for instance, which has only

FIGURE 52.—Cut-over land where fire has prevented adequate restocking.

about a third of its normal foliage to work with during the season following defoliation by fire may commonly grow only a third or half of the amount it otherwise would. It may largely recover in the second or third season from this checking of growth, or, on the other hand, recurring fire may again check growth so that if continued a definite stunting results (figs. 53 and 54). In this way the time employed in producing workable or salable material may be greatly lengthened. It is, on the other hand, true that when conditions are favorable fire may run over the ground bearing a stand of timber and produce very slight apparent effect on the trees. Especially is this true in stands of longleaf pine where fire is used intentionally at favorable times, for example, in winter after light

rain, or at night when there is no wind. In the past definitely-set fire has been extensively used by turpentine operators and others in the South as a means of safeguarding timber against the effects of untimely and more destructive accidental burning. In destroying competing species (*134, 254, 269*) and undesirable small growth it

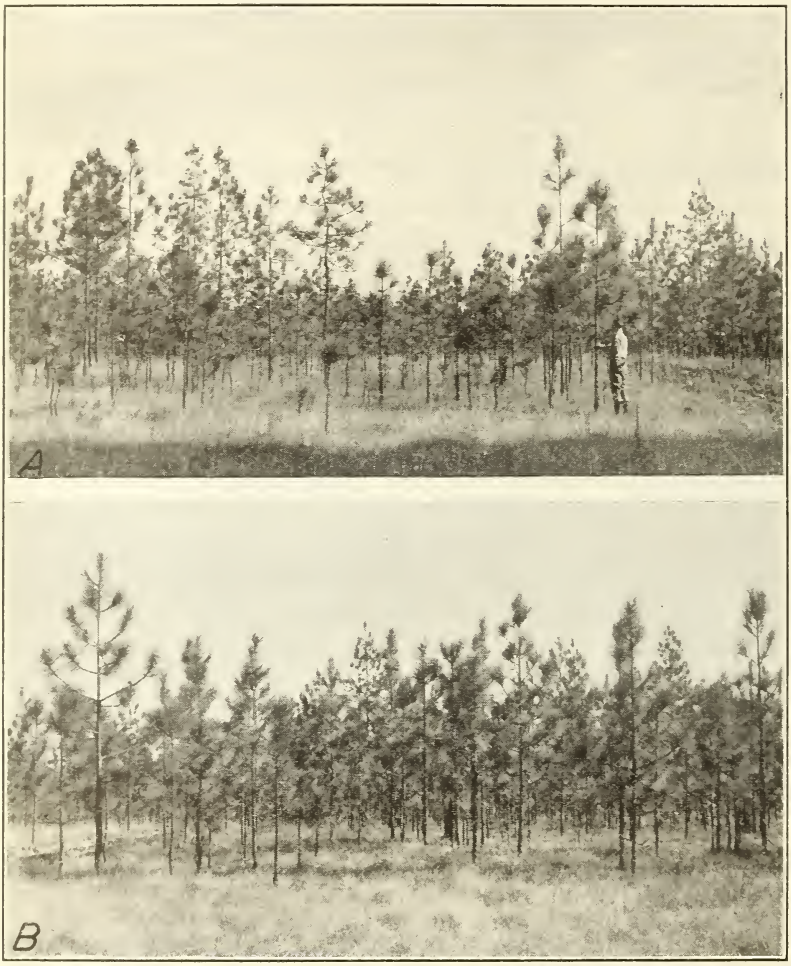

FIGURE 53.—Effect of fire on young longleaf pine: *A*, Twelve-year-old trees on land burned annually; *B*, trees of the same age protected for 5 years from fire.

would seem also to reduce root competition for soil nutriment and moisture. It has even been maintained in other countries that fire may serve to thin and to reduce competition in dense young stands in a desirable way (*257, 534*). On this point really systematic information is not available for slash and longleaf pines, but general

FIGURE 54.—Effect of fire on growth as shown by last 4 years' growth at the tops of two longleaf pines. Tree on left grew on land protected from fire. Note height and well-developed buds. Tree on right survived repeated fires but was retarded in development and reduced in wood formation.

indications are that results are so variable that fire as a means of thinning can seldom if ever be usefully employed (fig. 55).

Fire, furthermore, appears to affect the condition of the soil so that the rate of growth of the trees may be definitely influenced (*29*, *556*). The unburned forest land accumulates a layer of dead

FIGURE 55.—The possibility of using fire as a thinning agent presents great uncertainty. *A*, *B*, and *C* show results of a single May fire in a slash pine stand: *A*, Seven-year-old tree killed by the fire; *B*, only part of the trees were killed on this area which was close to *A*; *C*, none of the trees was killed on this area adjacent to *B*.

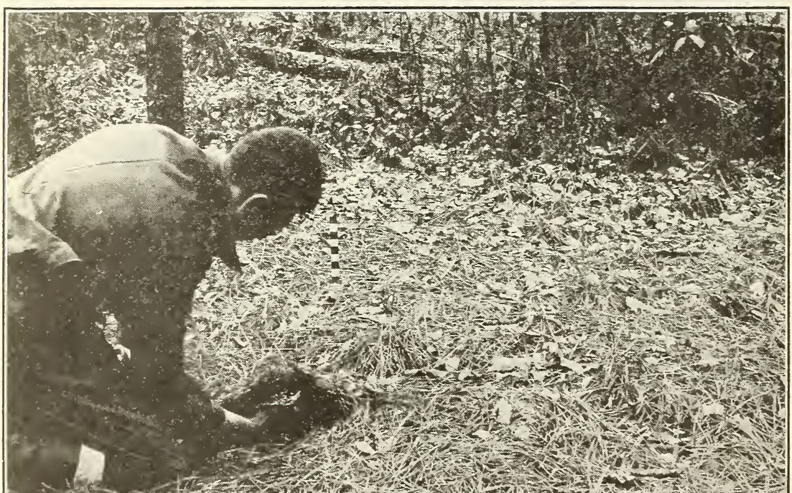

FIGURE 56.—Layer of leaf litter on forest floor where fires have been excluded. (The ruler is marked in black-and-white inch squares.)

needles and other organic matter (*380*, *381*) that, on some soil types at least, may serve as a useful mulch (fig. 56). In some localities, however, under high temperatures and prevailing moisture conditions, this layer is very thin; the decomposing litter in such cases

appears to oxidize and disappear nearly as fast as it falls. Other observations indicate that where land for a considerable period has not been burned the soil underneath the litter may be more mellow, permeable, and friable and contain more fungi and channels of

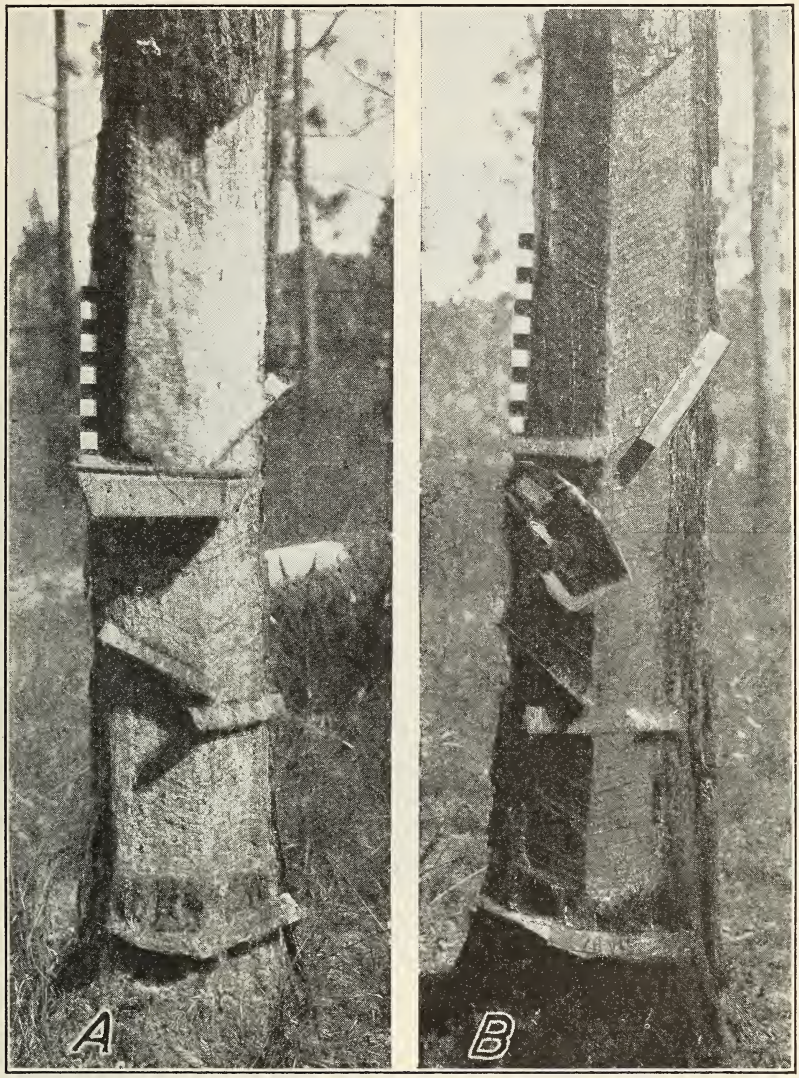

FIGURE 57.—When fire sweeps through the turpentine woods great damage is done unless the trees are protected from burning: *A*, Unburned face covered with scrape; *B*, burned face, gum lost, cup ruined, tree possibly killed or dry-faced, certainly so charred that it will discolor and degrade any gum that traverses it for some time. (The black and white rule on tree is marked in inch squares.)

worms and insects than the compact, impermeable soil not covered with litter that is found on burned areas. These porous soil conditions would appear also to favor growth of timber. At the same time the results of some experiments in Mississippi show a high

moisture, organic, and nitrogen content in the samples from the burned areas (*55*, *90*, *254*, *294*). The actual correlation is often difficult to prove, and comprehensive studies on many sites are needed to clarify and reconcile information now available. It is also known that fires burning year after year in mature timber stands cause degrade and damage among large and valuable trees, even though the trees are not totally destroyed (*47*, *163*).

The experiments conducted at the coastal plain experiment station at McNeill, Miss., have also demonstrated that under the conditions existing there and under the method of combined tree growing

FIGURE 58.—Customary raking away of inflammable material from the base of the trees preliminary to controlled use of fire to burn off the ground cover.

and livestock management on fenced land that were followed, ground fires were found beneficial in livestock production (*252*, *253*, *254*). The extent to which these results are applicable in other portions of the southern pine belt or under different methods of livestock management are not fully known.

In the turpentine woods great damage may be done by fire unless the trees are protected from burning (*48*). Turpentine operators in the past have used supervised burning at times of relatively low fire hazard as a means of protecting the stands of worked trees from

damage by accidental fires which might ruin both timber and equipment (fig. 57).

To protect the turpentined faces it is customary in late autumn or early winter to rake away all inflammable material for 2 or 3 feet around the base of each tree so that the bare ground serves to check the fire (fig. 58). However, since organized fire protection has been gaining ground in the South the practice of raking and burning, which in the case of a serious fire may give considerable protection to individual trees, has been given up by many operators who now conduct their turpentining in the unburned woods and believe that they obtain more and cleaner gum in consequence. With this procedure it is customary to construct fire lines or firebreaks of different types which serve to check the spread of accidental fires (figs.

FIGURE 59.—In recent years protection against fire by the use of prepared firebreaks has replaced raking and the customary burning of the entire ground cover.

59 and 60). This work also serves to give between-season employment to the hands on the turpentine farm. It has been found by operators who have kept strict account of the expense incurred that under ordinary conditions the woods can be protected against the entrance of fire at no greater cost than that entailed by raking and burning (*558*).

Protection of the southern pine forests from fire has spread rapidly in recent years. One reason for this has been the increasing appreciation of operators and landowners of the potential value of their property; another, the activity of forestry organizations in the several States (*203*, *496*) and the financial cooperation afforded the owner by them and by the Federal Government.[26] Look-out

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[26] Specific information about organizing such work can be obtained from the State forester's offices in the respective States or from the Forest Service, Washington, D.C., upon request.

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towers have been built and provided with telephones (fig. 61, *A* and *B*); community timber protective associations have been organized locally and equipped for the detection and suppression of fire. Firebreaks have been constructed and specialized equipment, such as gang plows hauled by tractor, that leave behind them broad strips of upturned soil, have been devised and rather widely employed (fig. 60). Educational forces have also been actively at work among the people at large, their efforts directed particularly toward the school children. The example of fire-prevention measures employed on large private holdings, numbers of which during recent years have

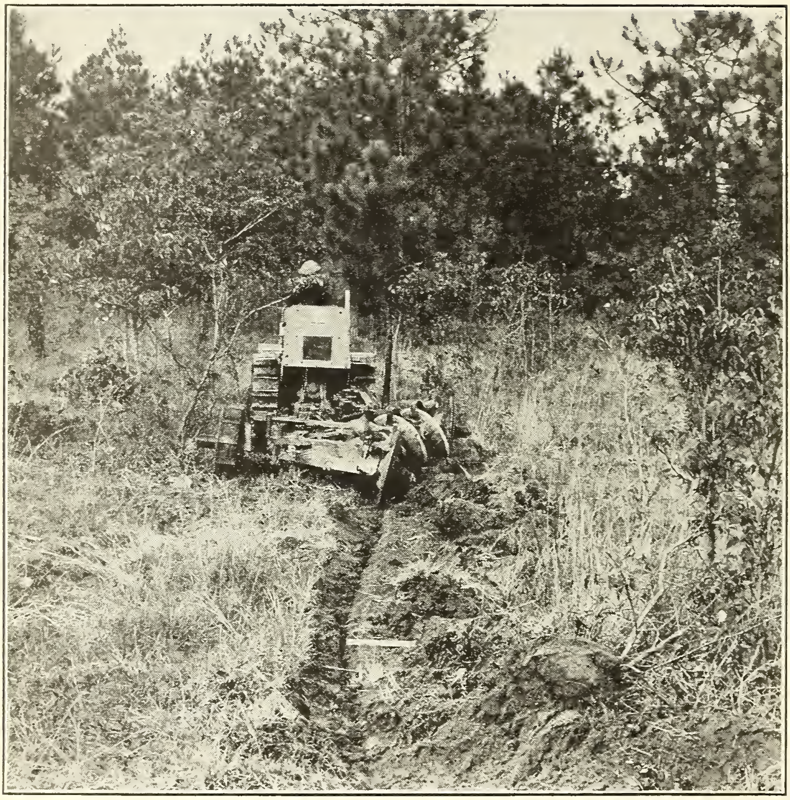

FIGURE 60.—A gang disk plow which has been found highly efficient for use in constructing firebreaks.

been placed under definite management for the purpose of timber growing, have given this endeavor added significance (*76*, *429*).

Yet the risk of destruction from careless woods burning cannot be considered as eliminated. Advance burning of the woods to be turpentined by naval stores operators is a long-established protective measure and is still continued. Under present conditions the decision as to whether or not to use controlled burning depends very largely on the characteristics of given pieces of property as related to good will and interests of the surrounding populations and the probable effectiveness of protective endeavor.

GRAZING

CATTLE

Cattle grazing (fig. 4) after stands of saplings are established and several feet high, does not appear to be incompatible necessarily with successful timber growing (*90*, *95*, *238*, *427*, *540*). Under present management plans cattle can also find good pasture on the firebreaks surrounding many forest stands, especially on those where carpet grass (p. 5) has become established. The cattle, moreover, aid in keeping down the growth which under some conditions may become a serious fire hazard. One head per 7½ to 10 acres is considered a

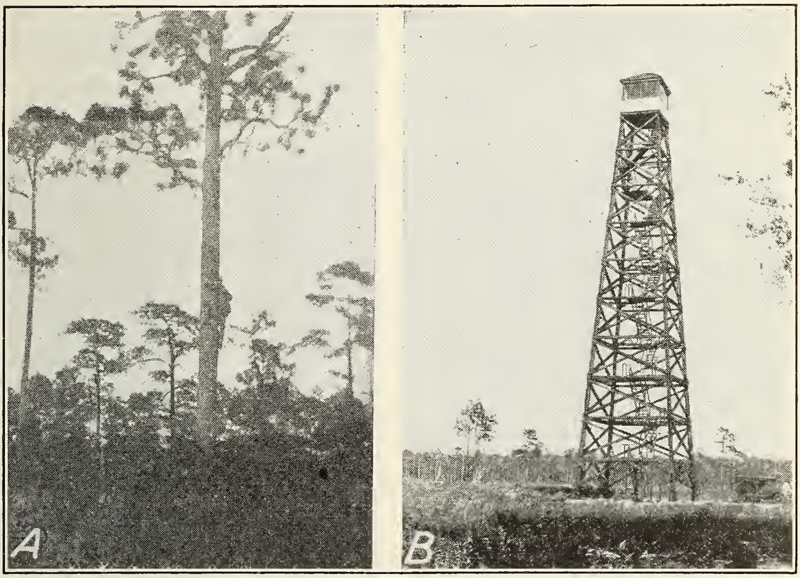

FIGURE 61.—*A*, Spikes driven in tall trees have served to enable lookouts to climb high enough to see a wide extent of territory; *B*, Towers with full-time watchmen stationed at the top increase the chances of early detection of fires. This 80-foot wooden tower was erected in Florida in 1933.

safe stocking to guard against overgrazing. The use of salt for attracting cattle to certain areas where grazing would be beneficial might well be introduced in the South to the probable advantage of both the cattle and the timber.

Information on means for improving the type of cattle either for stocking the open range or to be kept isolated from other herds in fenced pastures may be obtained from the Animal Husbandry Division of the Bureau of Animal Industry, Washington, D.C. The improvement of forage crops also has been studied by the Bureau of Plant Industry and the various States (*315*).

SHEEP AND GOATS

Sheep have been raised successfully by using the southern longleaf and slash pine woods for their pasture range (*3*, *346*). When the leaders of the young trees are well above the brousing reach of these

animals and where the stands are sufficiently open or there are fire-breaks, sheep, if given adequate care and protection, are to be regarded as a possible addition in the full utilization of the resources of this area. Goats as pastured formerly have caused marked damage to young pine reproduction by destroying the terminal buds, although they probably do little damage to the older trees.

HOGS

Razorback hogs and occasionally more domesticated breeds can readily wipe out young stands of longleaf seedlings even when the stands are 5 or 10 years old (*295*, *296*). They destroy the young seedlings by girdling them at and below the surface of the ground where the heavy inner bark offers tempting food. Even in well-grown saplings they may do much damage by stripping the inner bark from the surface roots.

A man who purposely followed a razorback hog from 8 a.m. to 4 p.m. (when the hog left the woods) saw the animal root out 400 trees. Hogs also eat the eggs and young or wild turkey, quail, and other birds which nest on the ground [27] and consume longleaf pine seeds that lie on the surface of the ground and which might otherwise produce young trees.

Slash pine is not immune from attack by hogs, although it is much less frequently attacked than longleaf pine. Instances of the destruction of more than occasional slash saplings have however been observed. There is a record of damage done by hogs to a considerable stand, including one third of all the slash pines from 1 to 6 years old on a 40-acre tract (*293*). Sometimes the tap roots were excavated to a depth of 10 to 12 inches and the laterals were uprooted for 8 to 12 feet from the trunks of the trees.

INSECTS THAT ATTACK SOUTHERN PINES [28]

In comparison with other forested regions, broadly speaking, the pines of the Coastal Plain are unusually free from insect pests. Occasionally, when preceded by certain weakening influences, such as prolonged drought or serious fires, certain insects play an important part in bringing about the death of these pines throughout extensive areas. Destructive methods of turpentining result in heavy infestation by the turpenine borer, and plantations of loblolly pine are subject to serious damage by the tip moth in certain regions. Unseasoned wood products, such as recently felled logs and freshly sawed lumber, are likewise injured at times if not properly handled. However, the grower of pines in this region has little to fear from insect pests if he follows sound and conservative practices in handling and operating his timber (*15*, *27*, *149*, *571*).[29] The keynote of insect protection is prevention. The more important insects (*152*) which cause losses from time to time are briefly discussed in the following paragraphs. More detailed information can be obtained from the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D.C.

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[27] WHEELER, H. N., RAZORBACK DESTROYS YOUNG TREES. U.S. Dept. Agr., Forest Serv., Bull. 15 (18) : 8. 1931.

[28] By F. C. Craighead, Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine.

[29] WYMAN, L. See footnote 20 on p. 82.

THE TURPENTINE BORER (BUPRESTIS APRICANS HERBST.)

Destructive methods of turpentining, especially excessively deep chipping and overcupping of trees of small diameter, have resulted in an enormous increase of a flat-head borer known as the turpentine borer (*84*). This insect is a fairly large, flat, bronze beetle about an inch long (fig. 62, *A*). The grub, or injurious, stage varies from an inch to 2 inches in length. When young it is a slender creamy white larva with a broad flat head (fig. 62, B). The adult beetle lays its eggs only on trees where the wood has been exposed by a scar or wound, and is especially abundant on turpentine faces when they are burned or dry and checked. The grubs, which develop from the eggs, laid in these cracks mine extensively through the inner wood, often completely riddling it. This process may continue inside the tree for 3 years or more as a result of one infestation and thus the tree filled with hollow galleries (fig. 62, *C*) are weakened and made subject to windthrow. The adult beetles emerge from the trees in the spring. In some second-growth stands a high percentage

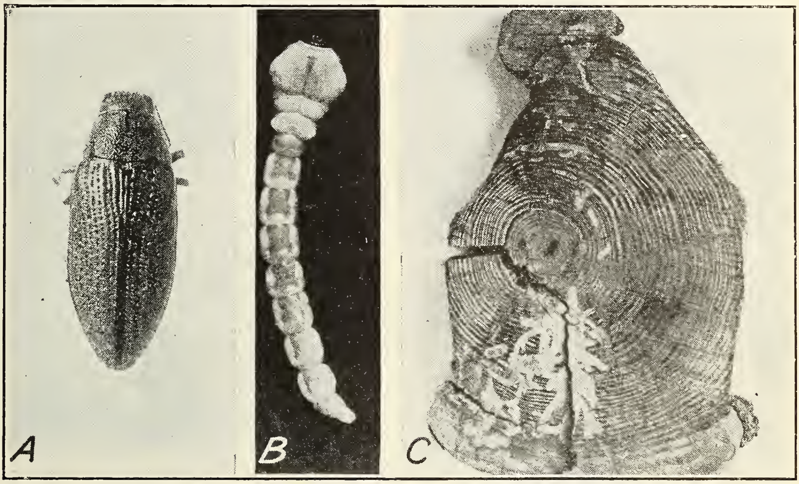

Figure 62.—A flat-head borer, known as the turpentine borer (*Buprestis apricans* Herbst.): *A*, The beetle which lays the eggs; *B*, the larvae which develop from the eggs and cut tunnels in the wood of the trunk behind the face; *C*, cross section of turpentined butt showing turpentine-borer galleries filled with powdered wood.

of the trees are blown over due to the work of this insect (*60*, *85*, *150*).

Attacks of this insect can probably be entirely prevented by the adoption of conservative practices in turpentining (p. 64). Particular attention must be paid to the use of narrow faces and shallow chipping. It is likewise important to tack the gutters on the face rather than insert them in an incision made in the chipped face with an ax. It is imperative that the exposed wood be kept covered at all times by a thin protective layer of gum. Consequently special care must be exercised in scraping so that large chips of wood will not be needlessly removed, thus deepening the scar and exposing the unprotected surface to drying. It is well to cut a fresh streak at the time of scraping so that the gum may exude and varnish the face

with a protective layer. Burned and fire-scarred faces become dry and cracked and are invariably infested. It is, therefore, important to maintain fire protection for all chipped faces while they are being worked and during their intervals of rest.

THE PITCH MOTH (DIORYCTRIA SP.)

Masses of pink or cream-colored pitch are frequently found along the healing edges of the faces, or about the edges of wounds. This resin flow is caused by the larvae of a small moth, which bores into these tissues. Although frequently abundant, they appear to cause little serious injury.

THE SOUTHERN PINE BEETLE (DENDROCTONUS FRONTALIS ZIMM.)

The southern pine beetle is the most destructive insect enemy of southern pines. Its activities are confined chiefly to the Piedmont region from Virginia to northern Georgia, but occasionally large

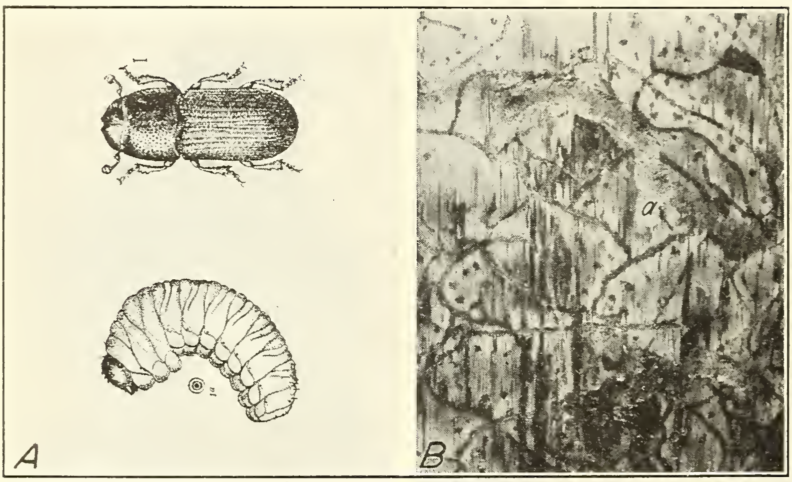

FIGURE 63.—*A*, Southern pine beetle (*Dendroctonus frontalis*, Zimm.) larva and adult form; *B*, tunnels and galleries of southern pine beetle in soft inner bark. Large galleries (*a*) made by the southern pine sawyer.

tracts of timber are killed by it within the Coastal Plain region. This is a tiny black beetle, about the size of a grain of rice (figs. 63, *A* and 64, *A*), which attacks and kills healthy vigorous trees from the sapling stage to maturity. Although longleaf and slash are occasionally killed, shortleaf, loblolly, and pitch pines are its favored hosts. These beetles, which fly from March to December, attack the trees in great numbers, boring through the bark, especially in the middle and upper portions of the trunk. They construct winding S-shaped galleries in the soft layer of inner bark (fig. 63, *B*). Along these tunnels eggs are laid which soon hatch into tiny, grub-like young. These larvae feed on the inner bark until full-grown, then bore out into the corky bark and are transformed into new beetles. The beetles in turn bore out through the bark, making exit holes that appear as if made by shot, and fly off, usually emerging

from March to December, to attack other trees. From 3 to 5 generations may be produced in 1 year. Infection by blue-staining fungi has been found to be associated with the attacks of this insect (*151*, *460*).

Shortly after the trees are attacked by the southern pine beetle the foliage begins to fade. Groups of trees with fading foliage and winding **S**-shaped tunnels beneath the bark are the most conspicuous features of outbreaks of the southern pine beetle (*300*, *303*, *463*,

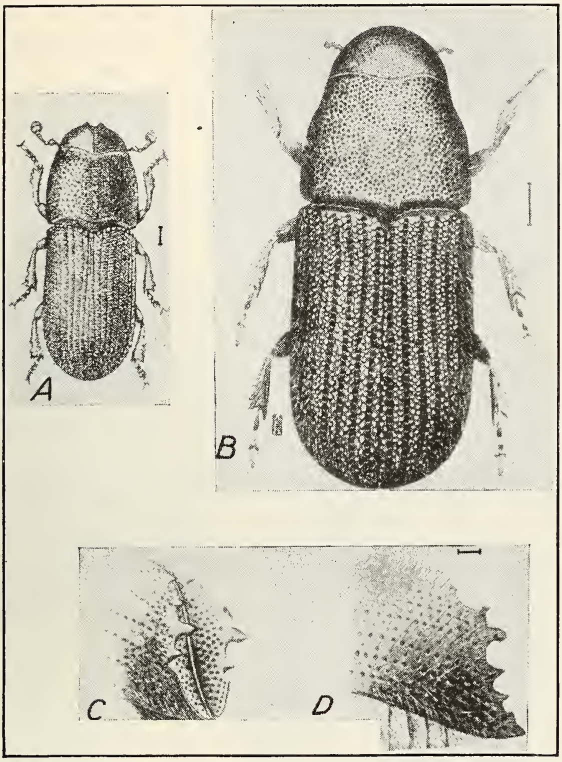

FIGURE 64.—*A,* The southern pine beetle (note end of abdomen gradually rounded out in a convex manner); *B,* one of the turpentine beetles similar in shape to *A* but larger; *C,* and *D,* parts of *Ips* bark beetles showing posterior end of abdomen scooped out and armed with toothlike projections. (*B, C,* and *D* after Swaine.)

465). Prompt control measures are necessary to prevent these outbreaks from spreading and killing more timber (*153*). Control consists in the felling of the infested trees and removing and burning the bark before the beetles escape. The appearance of a large number of "shot holes" indicates that the beetles have already left the tree and that treatment of that particular tree would be useless.

Most of the severe outbreaks of this beetle have occurred shortly after a marked deficiency in the normal amount of rainfall for the locality (*149*, *464*). Observations indicate that they originate on the higher, drier tracts of land and spread to other timber.

THE BARK ENGRAVERS (IPS GRANDICOLLIS EICHH., I. CALLIGRAPHUS GERM., AND I. AVULSUS EICHH.)

Three other species of bark beetles, of the genus technically known as *Ips*, somewhat resemble in appearance the southern pine beetle, but can be distinguished from it by the fact that the end of the body of the insect has the appearance of being chopped off, and is armed with several minute teeth (figs. 64, *C* and *D* and 65, *A*). Their habits and manner of working (fig. 65, *B* and *C*) are likewise very similar to those of the southern pine beetle and blue-staining fungus infection may also be associated with the attacks of these insects (*460*). These beetles rarely attack healthy trees, yet during periods of severe drought they have been known to contribute to the death of much longleaf and slash pine. They occasionally are injurious around small lumbering operations, where they breed in the slash and cull logs and become abundant enough to kill groups of young trees or an occasional large tree. As a rule control of these insects is unnecessary, but care must be exercised to prevent them from breeding in large numbers.

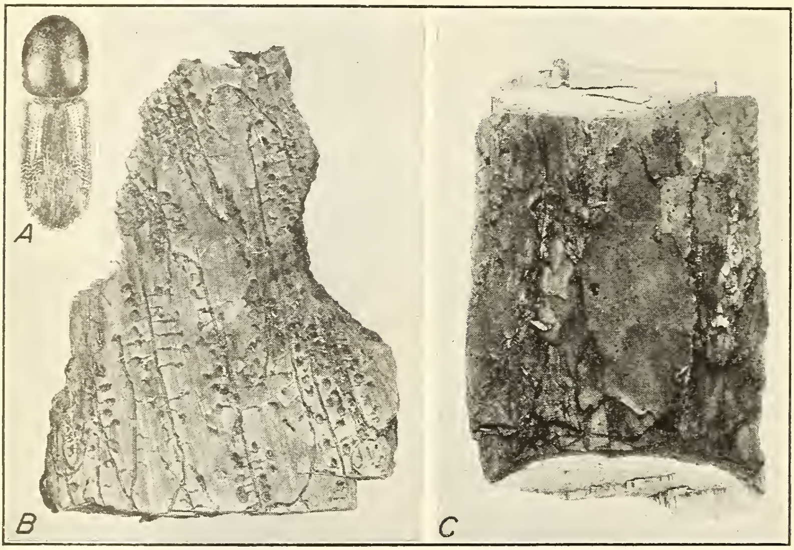

FIGURE 65.—*A*, Bark beetle *Ips calligraphus* Germ. (after Blackman); *B*, egg galleries and mines made by larvae of *Ips avulsus* Eichh. in bark of longleaf pine; *C*, emergence holes of adult beetles in longleaf pine bark.

THE BLACK TURPENTINE BEETLE (DENDROCTONUS TEREBRANS OLIV.)

In addition to the *Ips* beetles, there is one other which is identical in shape and is apt to be mistaken for the destructive southern pine beetle. This is the black turpentine beetle (*Dendroctonus terebrans* Oliv.).

This beetle is about twice as large in size as the southern pine beetle, being about one-fourth of an inch long (fig. 64, *B*). It often attacks the bases of pines which have become weakened through such

agencies as drought, fire, severe turpentining, or by being mechanically injured as the result of operations around newly constructed buildings or camps, where the cutting or wounding of pines has taken place. Their presence is readily detected by the large pitch tubes which are made near the base of attacked trees (fig. 66) and when the bark is removed by their long galleries about a half inch wide, filled with pitch and borings.

Although the grubs working together often completely excavate the soft inner bark around a portion of the base of the tree, they should cause little alarm, as they seldom, if ever, kill trees. Normally they breed in stumps and felled logs.

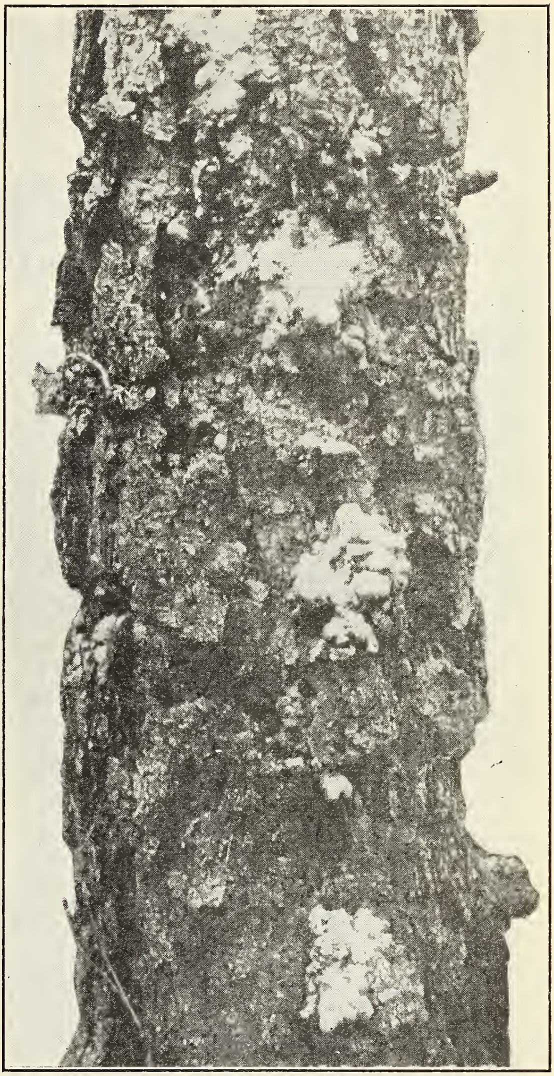

FIGURE 66.—Pitch tubes produced by the black turpentine beetle.

THE PINE TIP MOTH (RHYACIONIA FRUSTRANA COMSTOCK)

The pine tip moth is locally a serious pest in loblolly and shortleaf pine plantations and in natural reproduction. It has also been reported from a considerable number of slash pine plantations. It is mainly destructive to seedlings and to saplings up to 7 feet in height by greatly retarding the growth and prolonging the rotation of the stand, but after a height of 7 to 8 feet has been attained the trees are not seriously injured. Rarely does it cause any noticeable injury to the other species of pine. The adult stage of this insect is a tiny moth, and the injurious stage a small caterpillar which mines in the buds and growing tips of the branches. Practical control measures have not yet been worked out, but in small planta-

tions it is sometimes possible to collect the injured tips during the winter and by burning them destroy many of the insects. It is advisable not to plant loblolly and shortleaf pine in localities where this insect is known to be injurious (*245*), especially on the poorer sites.

THE SOUTHERN PINE SAWYER (MONOCHAMUS TITILLATOR FAB.)

Recently felled logs are frequently attacked by the southern pine sawyer, which is a large, gray mottled beetle with very long feelers

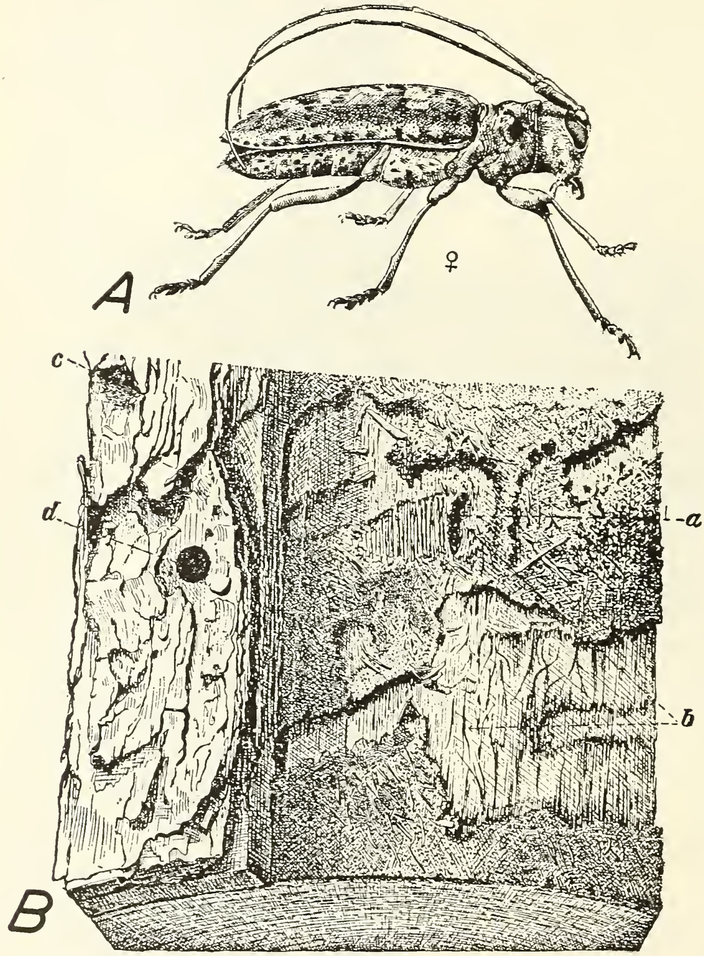

FIGURE 67.—*A*, Southern pine sawyer (*Monochamus titillator* Fab.) beetle; *B*, Section of pine showing, at right, mass of borings and refuse packed under bark (bark removed) by the larvae and channels made through the mass by the larvae: *a*, Entrance hole of larva in wood; *b*, scored surface of wood; *c*, egg pit; *d*, emergence hole.

(fig. 67, *A*). This beetle lays its eggs in small oval pits which it gnaws in the bark. The eggs hatch into grubs known as "sawyers" or "fish bait" which bore under the bark and through the sapwood (fig. 67, *B*). They frequently cause complete destruction of the wood. This beetle attacks only logs on which the bark is pres-

ent. All injury can be prevented by promptly sawing the log into lumber so as to slab off the bark. In the event of windthrown trees every effort should be made to salvage the timber promptly to save it from destruction by this beetle. A delay of 2 to 3 weeks during the summer months is a sufficient time for the grubs to penetrate deeply into the wood.

THE PINHOLE BORERS OR AMBROSIA BEETLES

Probably the insect which takes the greatest annual toll of felled lumber is a tiny beetle commonly known as the pinhole borer, or ambrosia beetle (fig. 68, *A*, *a*, *b*). Several species of these wood-boring insects occur in the South. They are brownish-black in color and vary in size from three-sixteenths to nearly one-fourth inch in length. The tiny holes which they bore in the sapwood and heart-wood of weakened and dying trees and in freshly cut logs and lumber (figs. 68 and 69) for the purpose of rearing their young,

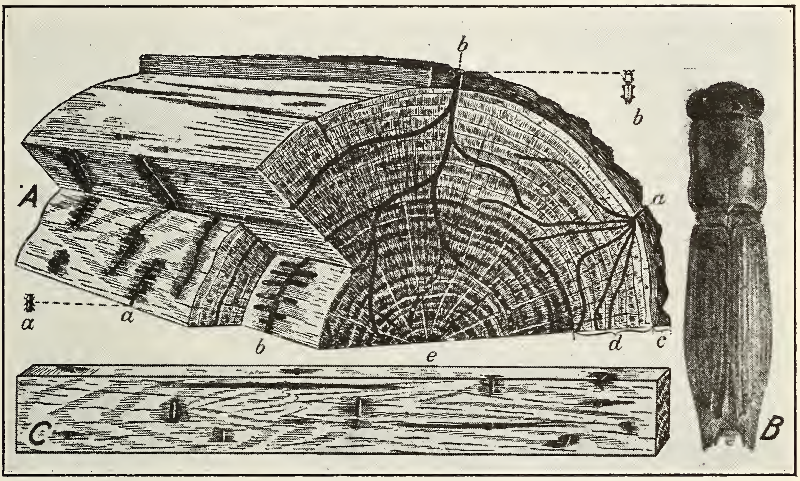

FIGURE 68.—Work of ambrosia beetles in oak (similar injury cause to pine): *A*, *a*, *Pterocyclon* (*Monarthrum*) *mali* Fitch and work; *b*, *Platypus compositus* Say and work: *c*, bark; *d*, sapwood; *e*, heartwood. *B*, *Platypus compositus* enlarged many times (after Blackman). *C*, character of work in lumber from injured log.

vary from one-hundredth to three-sixteenths of an inch in diameter. They are attracted to wood only when it is in a green and moist condition, because moisture is necessary for the growth of a so-called "ambrosia fungus" on the walls of the pinhole burrows on which the beetles and their young live. Therefore, any agency or combination of them which retards drying, such as leaving green logs in moist shaded places in the woods or placing freshly sawed lumber in close piles during the period of insect activity, will offer favorable conditions for insect attack. Under such circumstances trees, logs, and lumber may be severely damaged within a few days and in a few weeks reduced in value nearly 50 percent.

The most practical way of protecting green logs and lumber from pinhole-borer injury is through such methods as rapid utilization of the material and the rapid drying of the wood. The latter

can often be accomplished by making only slight changes in methods of management in the woods and in the mill yard which entails little added expense.

FIGURE 69.—Pinhole damage by ambrosia beetles, *Pterocyclon,* in both sapwood and heartwood of southern yellow pine.

ANTS

Occasionally in some localities ants may become a factor in determining the survival of longleaf pine seedlings. As soon as the seeds have germinated and sent out their long slender seed leaves,

often while still capped by the seed, the seedlings may be attacked by ants which bite pieces out of the tenderest parts. With the formation of the needles the attack ceases. A medium sized jet-black ant, *Cremastogaster lineolata* var., and a smaller brown-black ant, *Tapinoma* sp., were observed in such an attack on the Choctawhatchee National Forest (*219*).

THE EFFECT OF FOREST FUNGI [30]

Just as man at times becomes sick by infection with fevers, smallpox, or tuberculosis, so trees have their sicknesses from which they suffer and die or which they succeed more or less in resisting. The spores or "seeds" of the tiny organisms which cause tree diseases are not ordinarily visible to the naked eye, but they float in the air or exist in the soil, and if they can reach an exposed surface where there is enough moisture and food, they grow and work their way into the tree tissues, living either on the material of the cell walls such as the wood, or on the food and other materials which the tree has stored up inside the cells for its own purposes. These tiny disease organisms are plants of a low order. They are not capable of making their own food but appropriate the supply manufactured by other plants. These disease organisms are called fungi. Some of them cause the familiar defects of sap stain, rot, or dote.

Fungi are known to play a part both in the growing of slash or longleaf pine and in the utilization of the products. No thorough investigations of the fungi connected with these two pines have ever been made, and what is said here is based on scattered observations, interpreted in the light of the somewhat fuller knowledge available on the pines of the North and West.

FUNGI ENEMIES OF REFORESTATION

The amount of pine seed is much decreased in some localities as a result of the Florida pine cone rust (*Cronartium strobilinum*, Hedgcock and Hunt). Where pine grows in mixture with oaks, a rust fungus which lives on the oak leaves infects the cones of the pine, causing the cones to swell prematurely. Instead of seeds, these swollen cones produce only the yellow powdery spores of the fungus which serve to spread it abroad.

Of the pine seeds that are produced, many are rotted and ruined by mold fungi.

Those seeds which are good and which germinate either in nurseries or naturally in the forest are subject to fungi (for example *Pythium debaryanum* Hesse (*P. ultimum* Trow), *Corticium vagum* Berkeley and Curtis, and *Fusarium moniliforme* Sheldon) which kill the seedlings while they are still below the soil surface, or which cause them to damp off after they have begun to stretch up above the soil (*276*). This latter type of fungus injury is sometimes confused with death by drought, or by the heat of the soil which burns the stem of small seedlings just at the surface of the ground.

These damping-off fungi, together with some of the wood-destroying fungi, live in the soil and destroy parts of the root systems of older trees. Slow growth, which is often ascribed to soil exhaustion

[30] By Carl Hartley, Division of Forest Pathology, Bureau of Plant Industry.

or lack of moisture, is sometimes really due to such root sickness. Bad cases of root sickness may kill the tree outright, or result in windfall.

Some fungi may help trees. The roots of most pine trees after the first year are thoroughly infected with mycorrhiza, fungi which grow into or over the root tips, deforming the feeding roots without immediately destroying them (*360*, *426*). Some kinds of plants, such as certain of the orchids, cannot grow properly without such mycorrhiza. In the pines, however, the value of the mycorrhiza has not been satisfactorily proven, and some investigators believe them to be harmful.

Pine needles are often attacked by fungi. Young longleaf pine is especially susceptible to attack by the brown-spot needle fungus, *Septoria acicola* (Thüm.) Sacc., which gradually kills the worst affected seedlings and defoliates a great many others, resulting in slow growth, because their power to manufacture food is reduced when the needles are hurt. This is perhaps the most injurious foliage disease among seedling longleaf, and its occurrence on the foliage of other southern pine seedlings is general, although less harmful. The disease is found both in the forest and in the nursery (*279*). The relation of fire control to the amount of the disease has been and is still being investigated (*135*, *488*). This fungus seldom seriously affects the development of longleaf seedlings once the foliage attains a height of from 18 inches to 2 feet. Of less importance than the brown-spot needle blight are the needle rusts belonging to the genus *Coleosporium* (*280*). While these are wide-spread in occurrence, they do not usually cause enough injury to the foliage of individual plants to seriously affect development of seedling or tree.

WOOD-DESTROYING FUNGI

Heart rot of trunks and butts is less important in the turpentine pines than in some other trees. The best known causes of these two types of rot are *Trametes pini* Brotero ex. Fries and *Polyporus schweinitzii* Fries, respectively. On the other hand turpentined trees have a particular enemy in the sapwood fungi which enter the faces while they are being chipped, especially if they are unduly dry. Some of these make their presence known by staining the wood, while others are colorless (*469*). Most wood stain is due to species of *Ceratostomella* and *Graphium* which send dark-colored threads into the wood (*406*). *Trichoderma lignorum* (Tode) Harz also makes spore clusters on the surface of the wood which are green, but the wood in which the fungus threads are growing is not discolored. These fungi are thought by some to be carried from tree to tree on the hack, and are perhaps related to the matter of dry-facing which may even result in the death of trees. In absence of positive proof most observers do not consider the sapwood fungi of great importance for their effect on the living tree, except that their presence denotes unsatisfactory forest management or operating.

LUMBER DEGRADE

Fungi that cause blue stain reduce the value of the logs for saw timber when the tree is cut. After pines are felled, either before or after milling, the blue-stain fungi can work through them rapidly

under moist conditions, especially in warm weather. Although such wood may not be appreciably weakened, its appearance is injured and it does not bring so good a price as bright stock (*128*, *347*, *348*, *349*, *350*, *351*). Wood-rotting fungi also attack wood after trees are cut, working more rapidly in the climate of the Gulf States than in the North. *Lenzites sepiaria* (Wulf) ex. Fries seems to be the most important cause of decay in southern pine logs.

REMEDIES TO REDUCE OR PREVENT FUNGUS DEVELOPMENT

The cone rusts may be controlled by keeping oaks out of the stands. Damping-off fungi can be controlled in artificial seed beds by soil disinfection. Nursery stock can be protected from the brown-spot needle fungus by spraying with bordeaux mixture. In natural reproduction fire has the effect of decreasing the infection on the new needles for one or two following seasons but because of its harmful effects in other respects it should be used with much caution (*135*, *488*). Serious trouble from wood-staining fungi in standing trees can usually be avoided by regulating tree spacing and doing away with unnecessary butt scarring, deep cuts for gutter and apron insertion, and by conservative face width, and depth of chipping. Stain and decay of wood after it is cut are reduced to a minimum by surface treatment with antiseptics (*128*, *351*) and by getting the wood dried out as soon as practicable after felling the trees. Such additional information as is available on diseases of either the trees or their products will be furnished on request by the Division of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture, Washington, D.C., the Southern Forest Experiment Station, New Orleans, La., or the Forest Products Laboratory, Madison, Wis.

OTHER FOREST DWELLERS [31]

The poisonous rattlesnake, the moccasin, the copperhead, and the coral snake are present in the southern pine woods, yet fatal accidents to man are rarely recorded.[32]

Many thousand seedlings, however, have been sacrificed annually as a burnt offering in the cause of driving the snakes out of the woods which are to be turpentined (*53*, *168*). Yet since the practice of working the rough woods has been adopted by certain progressive operators it has been carried on successfully and there is a general feeling among these men that they would not return to old methods.

Birds, although they eat quantities of seed, also devour insects. For example, the woodpeckers destroy the young broods of bark

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[31] Compiled by Eloise Gerry, Forest Products Laboratory.

[32] Stout boots and leggings or puttees should be worn in the woods and a first-aid kit for the treatment of snake bite should be carried. It is recommended that this contain the following articles: Several single edge safety-razor blades; a small bulb and cupping glass for flat surfaces, with an additional attachment for round surfaces, like a finger; a roll of rubber ligatures; a small roll of bandage; and at least 2 tubes of antivenomous serum. The serum will remain efficacious for several years. A few permanganate crystals may also be carried (*30*). The purplish crystals of permanganate of potash, formerly recommended for treating snake bites, are considered to be of little value except as an accessory, used in dilute solution only, for the purpose of neutralizing the venom it reaches by oxidation. Antivenin may be easily administered, should be applied promptly (*169*, *170*). It may often be obtained from local druggists and doctors. Immediate but careful incisions with a sharp blade and mechanical removal of the venom by suction are of great importance.

beetles, and probably, with the exception of the yellow-bellied sapsucker, cause little damage to longleaf and slash-pine stands. Sapsuckers often destroy large amounts of the cambium and inner bark of the trees (*362*). Hawks and owls which prey upon rodents, help to control damage from that source.

Though seldom reported, rabbits sometimes cause damage by eating the tops of young pines.

Mice, rats, moles, and other rodents cause damage in nurseries by their burrows. They eat roots and seed. Squirrels, especially the large black fox squirrel, cause damage by eating seed and destroying the cones of pines, especially longleaf.

Deer, which are frequently the cause of damage in other forest regions, are seldom numerous enough to do much damage in the turpentine belt, although locally they sometimes eat the tops of young pines in plantations.

The harboring of quail (*509*), turkey, and other game birds in the forest opens another way to obtain revenue while producing a forest crop by means of leasing hunting privileges on these lands during the open seasons for game (*447*).

TAXATION AS RELATED TO GROWING PINE[33]

Much irregularity exists throughout the naval-stores region in regard to the taxation of lands producing forest crops. This subject is being investigated with a view to determining a reasonable ratio between revenue and taxation (*281, 307, 554, 555*). Other studies aim to work out and recommend practical measures for handling and using forest lands which have reverted to public ownership on account of delinquent taxes.

There has been a great increase in tax delinquency because the tax burden cannot be met from current land income or forest income (*148*). In one Southern State, the area "sold" to the State for taxes amounted to 2,900,000 acres in 1925; increased to 5,900,000 acres in 1928; and to 6,900,000 acres in 1930. In 1933 this State held tax certificates on gross area of 16,875,000 acres or on 50 percent of the taxable area of the State (area includes land actually reverted to State title, plus that delinquent for 1 or 2 years' taxes but still subject to redemption). In the other States of the active naval-stores region, delinquency is not excessive, however it is estimated that in 1933 the area of all land on which these States hold tax certificates does not exceed 800,000 acres. In the extreme western part of the naval-stores region (not now included in the active region), delinquency is again excessive. For example, in 1933 one State held tax certificates on a gross area of about 960,000 acres in the longleaf-slash pine belt. This area is equivalent to 9.5 percent of the gross area of the naval-stores belt included in the State.

In one county in the eastern part of the turpentine belt, it was found that improved farm lands were assessed at 26 to 27 percent of their sale value, whereas unimproved property including timberlands was assessed at 47 to 49 percent of its sale value, showing the heavy burden placed on this class of property (*580*). In the western part of the naval-stores region referred to previously, even more drastic differences occur. Improved farm lands are nominally

[33] By R. B. Craig, Southern Forest Experiment Station.

assessed at 27 to 30 percent of actual sale value, whereas cut-over timberlands are assessed at 90 to 123 percent of their sale value. In five counties in the southeastern part of the naval-stores belt, the taxation charges per acre in percentage of sustainable forest income were 13, 18, 67, 74, and 167, respectively. Actual taxes per acre ranged from 13 to 56 cents (*579*). In 2 counties in one Southeastern State, taxes on forest lands were 9 and 15 cents, respectively, but in 8 other counties they ranged from 19 to 56 cents per acre per year (*244*). In 5 counties in 1 State in the extreme western part of the longleaf-slash pine belt, average taxes on timberlands in 1931 ranged from 15 to 30 cents per acre per year, and in some districts to 51 cents per acre.

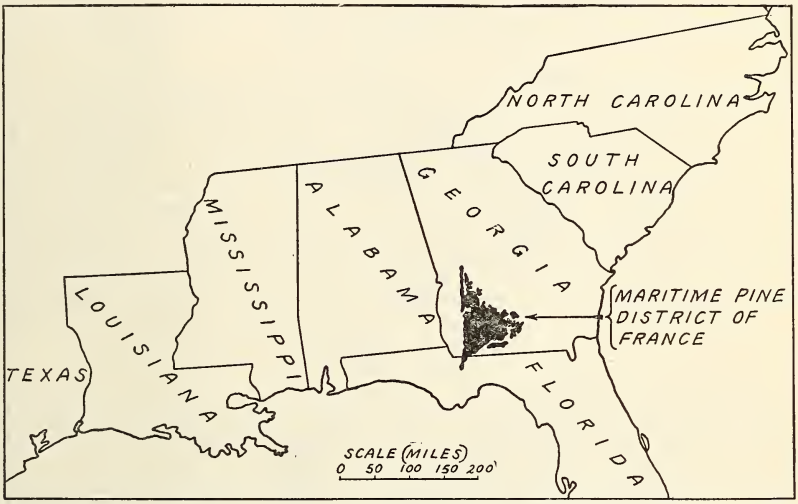

FIGURE 70.—Maritime pine district of France drawn to scale on the Southern States.

Low taxes averaging 4 to 8 cents per acre per year plus rapid growth of turpentine timber have combined to keep delinquency at a minimum in other States of the naval stores belt. It appears from these figures that taxes have been excessive in many counties and only where taxes are reasonable, and where young stands of turpentine pines are fairly well stocked, can the financial basis of long-time timber growing for naval-stores production be regarded as promising.

NAVAL STORES PRODUCTION IN OTHER COUNTRIES

FRANCE[34]

STATUS OF THE INDUSTRY AND HOW IT DEVELOPED

France is and has been for some decades the strongest competitor of the United States in naval-stores production (*32*, *35*, *80*, *107*, *109*, *183*, *206*). On an area of about 2,000,000 acres, roughly equivalent to 4 or 5 Georgia or Florida counties (fig. 70), France produces an-

[34] Compiled by Eloise Gerry, Forest Products Laboratory, chiefly from the writings and other information furnished by Austin Cary, Branch of Public Relations.

nually about 20 percent of the world's naval stores[35] or almost one-third as much as the United States (fig. 1). French production fluctuates slightly from year to year. It could probably be expanded somewhat though not greatly, but it is a sustained produc-

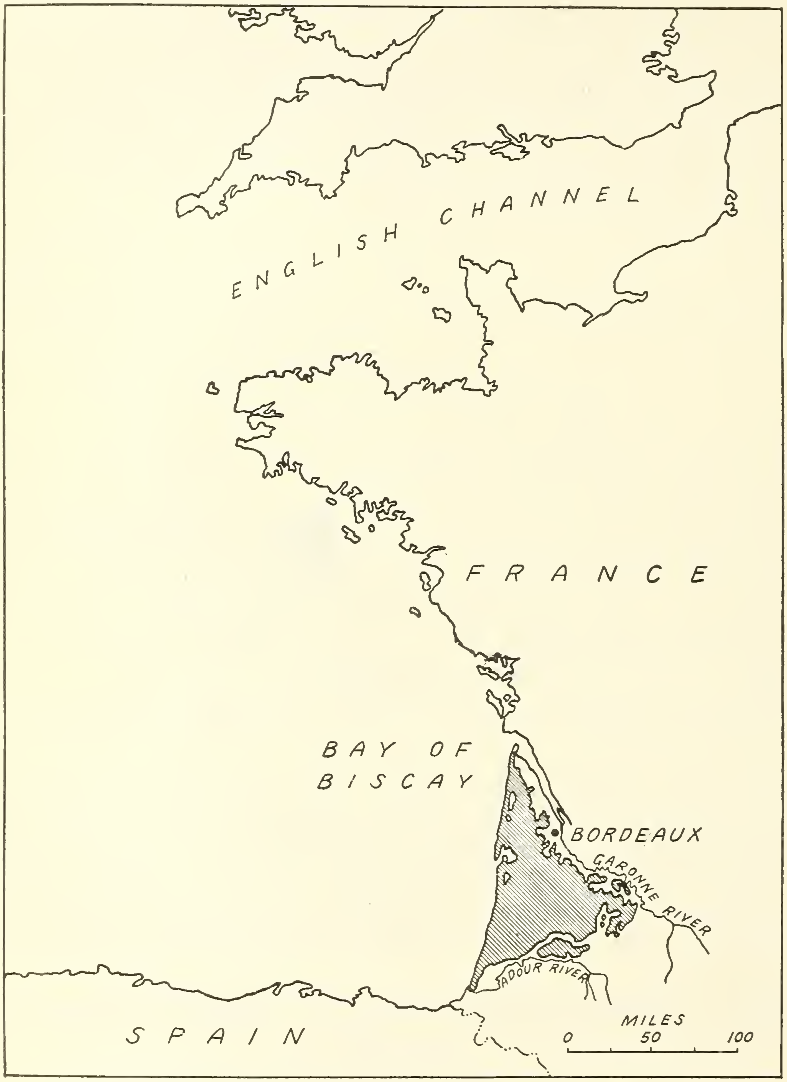

FIGURE 71.—Geographic relations of the chief French maritime pine region.

tion, the yield of managed forests, so operated and renewed that fresh timber is available as soon as the working of the older trees is completed.

[35] In 1929–30 France produced one hundred and sixty thousand 50-gallon barrels of turpentine and the corresponding rosin (*78, 79, 214*).

The chief naval stores producing region of France forms a triangle with the Bay of Biscay bounding the long side. The Garonne and Adour Rivers approximately define the other boundaries (fig. *71*).

Many centuries ago the virgin forest passed in the Landes region of southwestern France. After the timber was depleted the country was given over largely to grazing. Fires swept over it preventing the reproduction of timber, then came drifting sand borne in from the exposed area along the coast. Farms and even towns were buried by the sand, and drainage was blocked so that unwholesome conditions made this one of the poorest sections of France. Then began the reclamation, the drifting sand was checked, forest planting began about 1800, was carried on extensively, and drainage and transportation systems were developed. The result stands as a significant instance of mans' success in improving his environment (*18*, *297*, *313*).

Naval-stores production, stimulated about 1860 by the Civil War in the United States when products from the Southern States were not available, has become an increasingly important industry in the Landes region with the advancing years. Scattered through the area, and connected by a fine system of highways, are permanently constructed distilling and wood-working plants. About these, as a nucleus, are gathered thriving villages, the home for generations of the forest workers. The standard of living of these workers now compares very favorably with that of any other French workers (*54*, *72*, *81*, *172*, *222*, *387*, *563*).

FRENCH PINES

Maritime, strand, or cluster pine (*Pinus pinaster* Solander or *P. maritima* Linnaeus) is the chief producer of gum in France (*13*, *51*, *56*, *107*, *167*, *174*, *175*, *223*, *316*, *335*, *336*, *337*, *338*, *343*, *391*, *410*). Aleppo pine (*P. halepensis* Mill.) is also used to a small extent. It grows well along the Mediterranean coast.

Maritime pine is a native of southwestern France. It also occurs in small areas on the Mediterranean slope and elsewhere. It somewhat resembles loblolly pine in bark and foliage. There is a marked tendency for trees to be crooked and much branched. The cones are similar in shape and size to those of slash pine. Lime in the soil does not favor the development of maritime pine. Moisture notably affects growth. Trees naturally send their roots deep into the soil; they grow well on the sand dunes along the coast but respond with increased height growth when growing in depressions where moisture is more abundant. On the hardpan soils prevalent in southwestern France height growth is reduced, extremely so in some cases. Trees may attain a total height of 60 to 85 feet in about 60 to 70 years. Exceptional old trees may even be 140 feet in height and 5½ feet in diameter. Seed is usually produced abundantly each year after trees are 12 to 20 years old. Therefore reproduction is generally natural and easy.

OLEORESIN CONTENT

Maritime pine wood has a resin content of only 1 to 2 percent. In old stumps it may be 8 to 9 percent (*78*). The structure of the wood and the distribution of the resin passages are similar to those of the southern pines in the United States.

TURPENTINING METHODS

The French methods differ from those used in the United States in many respects (*342*). The maintaining of the good health and producing power of the trees during the main period of exploitation (gemmage à vie) is a foremost consideration and one which could, with advantage, be given greater attention in the United States. It is not until the final working that heavy chipping (gemmage à mort), designed to obtain as much gum as possible, is used.

RELATION BETWEEN LANDOWNERS AND OPERATORS

In France quite commonly the owner of the timber does not himself turpentine it but turns that work over to a still owner, or other operator. The owner generally furnishes the cups, aprons, and barrels. The operator supplies the tools and the labor. The cost of transporting the gum to the still is divided. The timber owner and the operator finally divide the price paid for the gum at the still. In 1931 the operators were receiving more than half of the value of the gum as their share of the returns. Operators and owners each have their own organizations so that concerted group action is possible. The operator takes a personal interest in the woods work for he has much to gain, in the long run, from seeing that it is well done. Moreover, his share of the returns from the gum may be reduced if he kills the trees he is working.

FIRE IN THE WOODS

The French have a fire problem not unlike that in the United States and are dealing with the situation by organized effort directed toward fire prevention and suppression.

REMOVAL OF OUTER BARK

The first operating step is the removal, generally in January, of the outer bark over an area about the size to be occupied by the chipping of the year.

SEASON OF OPERATION

Turpentining is carried on during a period of about 9 months from March to November, as in the United States.

FREQUENCY OF CHIPPING

Chipping is usually done once a week but during the warmest weather trees are often chipped once every 4 or 5 days. The total is usually about 40 chippings a year.

CUPS

Clay cups holding a little less than 1 quart are used for collecting gum (Hughes system). About 7 or 8 dippings are made each year. Cups are raised at least once each year, sometimes oftener. The French have used cups for some 40 or 50 years. Instead of using "boxes" cut in the butts of their trees, they formerly col-

lected the exuding gum in hollows dug in the ground at the base of the tree. The apron which is inserted in the tree is a curved piece of metal (fig. 72). A nail below the cup holds it in place against the apron.

TOOLS

The tools used in France for turpentining are illustrated in figure 73. The basic method of chipping differs from that used in the United States. The movement used when chipping low faces with the adzlike tool with its curved blade is a first crosswise and later, as the height of face increases, a downward cut so directed that it slices slantwise across the face. The freshening of the high faces is accomplished by a more directly downward stroke. The youths of the country are trained by their elders in the art of chipping and gain the required skill through long apprenticeship in this which is to be their life work (fig. 73).

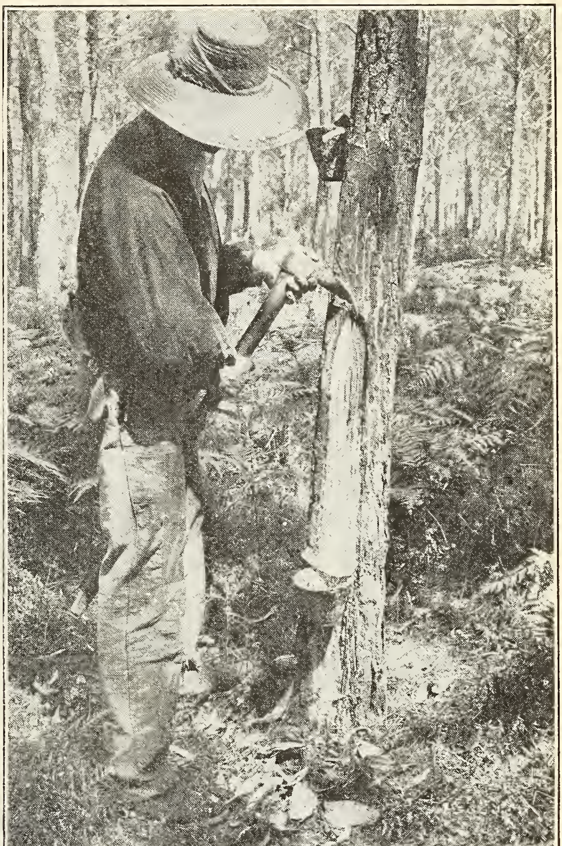

FIGURE 72. Chipping in France. Note clay cup, curved apron, and use of chipping tool.

FACE

The shape of the French face is an inverted U (fig. 72). It is about 4 inches in width, narrowing slightly as its height increases. The original face is made by a crosswise cut of the chipping tool and is about 1½ inches in height and 3½ inches wide. At each chipping the height is increased by one-half inch or more. An area of about 4 to 6 inches in height of the old face is also freshened at each chipping. In this way more of the tiny horizontal resin passages are reopened than by American chipping (p. 30). The depth of the face is about one-half inch at its deepest point. This depth is graduated from the center outward so that at the edge only a very shallow cut is made into the wood. The total height of the face cut during one season is about 30 inches, a height even greater than

that now common in the United States and probably greater, as results in the United States indicate, than is desirable for best results (*230, 367*). One face is usually worked for 4 years. A year of rest is usually allowed between the workings of successive faces.

THE CHIPPER'S TASK

A chipper may chip about 7,000 French faces and collect and market their product.

FIGURE 73.—French tools in use. Showing an apprentice at work on a low face and the practice of chipping high faces. High faces are now rarely used because they have proved uneconomical.

YIELDS

The relatively narrow French faces, which are from 3½ to 4 inches wide, give lower yields per face than those generally obtained in the United States. The return estimated on the basis of a crop of

10,000 faces ranges from 13 to 30 barrels (American) of turpentine, the average being about 20 barrels, together with the corresponding rosin. The gum has been found to contain about 20 percent of turpentine and 70 percent of rosin with about 10 percent of impurities (*78*, *537*).

FOREST MANAGEMENT

The fact that the French produce almost one-third as much naval stores as the United States, although the latter has a possible pine-growing region about 30 times as large, presents weighty evidence concerning the effectiveness of practical forest management. Land ownership in the pine region of France is of all types. It includes about 20 percent owned by the central Government, with its forests administered by trained foresters. These are made up of reclaimed land on the shore and protect the area farther inland. The communes, which may be likened to miniature counties, own still more land which also was reclaimed by planting and drainage. Forest management is regarded as a desirable business and there are numerous properties of 5,000 to 10,000 acres. The owners of some of these operate their own stills and sawmills. Others practice forestry, but sell the forest products to manufacturers. As in the United States, there are also small holdings in the hands of farmers and other private individuals. These holdings are regarded as normal investments and are definite factors in the life of the community.

The period of a forest rotation may be described as consisting of three parts.

First comes the preparatory period, which is practically without returns. Reproduction is generally not difficult, but heavy brush growth is sometimes an obstacle which has to be overcome. The ground is seeded by the old trees before their removal. Exceptional areas now and then require some planting. Systematic thinning and removal of brush are practiced. The first thinning usually comes when the trees are about as tall as a man. Thinning is repeated at about 5-year intervals in order to select the most promising trees and to insure proper spacing for their development. This work is a source of winter occupation, and although it is relatively costly, the French believe that it pays. Markets are sometimes found for the thinnings for such uses as vineyard stakes, but little return is expected till the trees are about 20 years old and have attained a diameter of about 7 inches and a height of about 40 feet.

The second period is that of severe working and prompt cutting, but of a selective type, with strict reference to the final yield from the forest area. At the beginning of this period the trees stand about 300 to the acre and may be selected and turpentined for the first time. The timber from these trees, when turpentining is completed and they are cut, can be sold for mine props, and in some instances for pulpwood (*176*). This constitutes an important thinning and after it there is left on the ground a fine stand of well-spaced and well-formed trees that number about 80 to 100 to the acre, the trees of place.

The third period covers about 20 years during which these highly productive trees, the final crop, are very carefully turpentined until

they are about 60 or 70 years of age. This includes a succession of workings using 1 or 2 narrow faces per tree at a time in such a way that the normal growth of the trees is scarcely reduced (fig. 74). The trees are then sufficiently large to yield saw timber, for which there is a local demand (*91*, *312*). There are many instances of trees worked for longer periods, but that just described is regarded as a very satisfactory arrangement.

A wise owner has tracts of land in each of the three conditions described (fig. 41) and so receives constant financial returns, which for some decades past have proved satisfactory.

FIGURE 74.—A disk from a pine turpentined for many years: *a*, An old face completely healed over; *b*, an old face recently healed over; *c*, recently worked faces; *d*, a face only partly healed.

ADVANTAGES OF THE FRENCH METHOD OF TURPENTINING

The naval stores industry in France is accepted as permanent, and the forests are managed to secure sustained yields with maintenance of tree health and vigor as a primary objective. Under the French system trees are not tapped to death until just before they are to be cut. This heavy chipping, however, may be applied to

small trees which are to be removed to improve the main crop as well as to old trees which have completed the full cycle of productiveness. The value of the gum is of primary significance as compared with other forest products in this plan of forest management. The personal interest and intelligent cooperation of skilled workers in the woods is secured. The gum is cleaned before it is distilled, and a very high quality of rosin is made.

INDIA[36]

STATUS OF THE INDUSTRY AND HOW IT DEVELOPED

The hillmen of India have long known how to wound the Indian pines, though crudely and wastefully, and collect the gum that

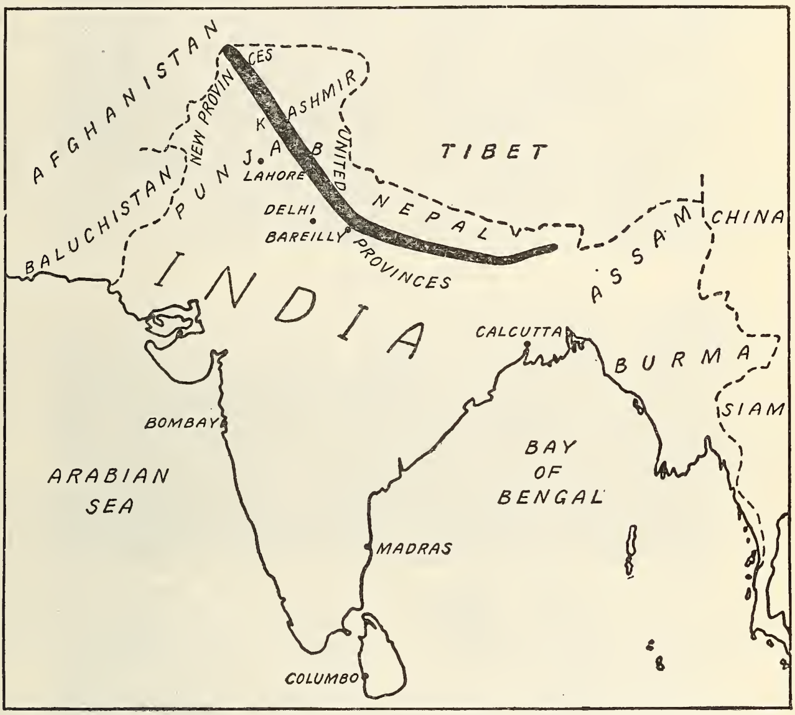

FIGURE 75.—The black area indicates the distribution of chir pine (*Pinus longifolia*) in India.

exuded. It was not until the establishment of a department of forestry by the British, however, that systematic turpentining began in India. With a forest area of approximately 160,000,000 acres, containing a large proportion of pine, the possibilities of supplying not only the local but also some export markets with naval stores

[36] Compiled by Eloise Gerry, Forest Products Laboratory, from the sources indicated. Material prepared primarily for this publication including information on wood specimens, sample tools, and photographs, as well as helpful criticism, was furnished by F. Canning, conservator of forests, eastern circle, United Provinces, India, and his associates, H. L. Cooper, J. E. C. Turner, and E. W. Raynor.

became evident. There are about 1,000,000 acres of chir pine in the Government forests which are situated chiefly in a long narrow belt in northwestern India (fig. 75). Although much pine timber also grows in Assam and Burma it is not now accessible. It is estimated, however, that about half of it should be workable with the promise of a good harvest. Moreover this area is more than equaled in extent in native states so that considerable expansion is possible. The production in India, though much smaller than either that of France or the United States (fig. 1), has increased and improved notably in recent years, and forests are being regenerated to take the place of those exhausted (*58, 89*). Experimental chipping carried on from 1888 to 1895 in the Government forests in the United Provinces demonstrated conclusively that chir pine could be successfully turpentined and that the products were salable (*5, 121, 192, 205, 234, 235, 236, 237, 259, 497, 521*). Since that time the production of naval stores has made a steady increase. It was conducted as a Government monopoly till methods were standardized. Two factories in which the Government retains a large interest now produce all of the Indian turpentine and rosin, and high standards are maintained for these products. Instead of having distilleries located in or near the forests the gum is transported often for long distances to the two central distilleries, where it is possible to carry on the distillation of the gum with expert chemical skill.

INDIA PINES

There are five species of pines native to India that are known to be capable of producing naval stores. Only one of these is worked commercially to any extent at present, although the others yield gum with excellent chemical constitution. The selection of this one species, chir pine, for working, is based primarily upon its accessibility.

Chir, or chil, pine (*Pinus longifolia* Roxb.) grows in very pure stands, some even 100 square miles in extent, on the southern slopes of the foothills of the outer Himalaya and Siwalik Range and also in the valleys of the principal Himalayan rivers at elevations from 1,500 to 10,000 feet (fig. *76*). This belt, which is about 1,300 miles long and 10 to 30 miles wide, covers about 1,500 square miles in Government forests and about 1,800 square miles in those of the native states (*520*).

Chir pine is a stately tree (table 16). Yield studies (*306*) show that the laws of growth for chir pine are the same in the hill country over the whole geographic area of the Himalayas. The rate of growth of chir pine is different in the plains, especially during the first 60 years, during which period it appears to be faster than that in the hill country but the finest hill chir overtops the plains specimens over 100 years old.

The leaves (needles or straw) of chir pine are 9 to 10 inches long, hence the name "longifolia", or long-leaved pine. The needles are in clusters of three. The cones are large and woody. Seed years occur at irregular intervals (*445*). This tree is capable of coppice, or sprout growth, after fire. The bark is 1 to 2 inches thick at the base.

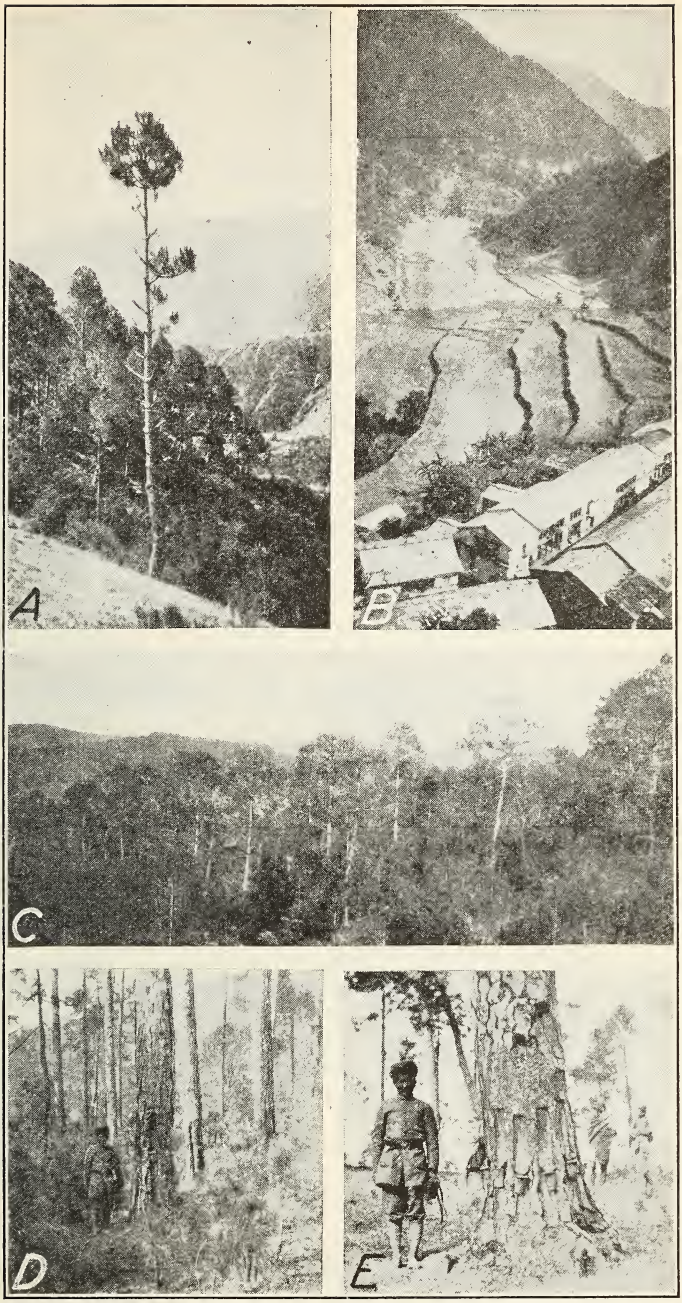

FIGURE 76.—*A,* Chir pine growing near a native village in India. The tree in the foreground has been damaged by the villagers who have lopped off the limbs for firewood. *B,* Typical country where turpentining is carried on. *C,* Chir pine forest in process of regeneration. Young trees are sufficiently established so that the old seed trees can now be heavily chipped for 5 years before they are felled and used. *D,* Chipping (end of season) in an area where controlled burning had been used the year before. *E,* Heavy chipping at the end of the second year. Note area of thinned bark above the numerous square-topped faces with their aprons inserted one-fourth inch into the chipped faces, and the covered cups.

TABLE 16.—*Measurements of chir pine growing under different conditions or site qualities in India*

Age	Site quality I [1]			Site quality II			Site quality III		
	Average diameter breast high [2]	Average height	Trees per acre	Average diameter breast high [2]	Average height	Trees per acre	Average diameter breast high [2]	Average height	Trees per acre
Years	*Inches*	*Feet*	*Number*	*Inches*	*Feet*	*Number*	*Inches*	*Feet*	*Number*
10	0.7	14.5	(3)	0.2	10.5	(3)			
20	4.0	30.0	1,008	1.6	21.0	1,500	0.6	16	(3)
30	7.2	45.0	389	4.3	33.0	743	2.2	24	1,553
40	10.2	62.0	219	7.0	45.0	355	4.3	33	584
50	12.7	77.0	155	9.3	57.0	225	6.4	43	318
60	15.2	90.0	114	11.6	69.0	158	8.4	53	213
70	17.7	101.0	88	14.0	80.0	114	10.6	63	153
80	19.9	111.0	73	16.3	89.0	88	12.8	70	110
90	22.0	119.0	62	18.5	96.0	70	15.0	76	83
100	23.9	125.0	54	20.5	102.0	58	17.2	81	64
110	25.1	130.0	50	22.2	107.0	51	19.0	84	54
120	25.9	134.0	48	23.2	110.0	47	20.2	87	48
130	26.4	137.0	46	23.8	112.0	45	21.0	89	44
140	26.8	139.0	45	24.2	114.0	44	21.5	90	42
150	27.0	140.0	45	24.4	115.0	44	21.8	91	41
160	27.1	141.0	45	24.5	116.0	43	21.9	91	41

[1] Site quality means the growing condition under which an average, well-developed tree will attain a given average height, that is, quality I at 50 years a tree will be 67 to 88 feet tall; on II, it will be 50 to 67 feet; and on III, 37 to 50 feet.
[2] Diameter breast high is the diameter outside the bark 4.5 feet above the ground.
[3] Many.

The gum of chir pine differs considerably in nature from American gum (*178*, *492*). It contains about 25 percent alpha and about 10 percent beta pinene, also about 38 percent carene and about 20 percent longifolene. The latter is a sesquiterpene, at present considered only as an objectionable constituent of the gum. Chir pine turpentine, if used without redistillation dries slowly and is greasy (*434*, *444*).

The wood of chir pine is a light reddish brown and is moderately hard, weighing about 33 to 38 pounds per cubic foot when air dry. It is used for building, for common furniture, tea boxes, railway ties (when treated), boats, and in general carpentry (*518*, *519*). Twisted grain is an extremely frequent defect (p. 118), and investigations indicate that it is an inheritable characteristic so that great care is now used to plant only seed that is known to come from straight-grained trees (*122*, *123*, *124*, *125*, *126*, *127*).

Four other species of pine occuring in India are known to yield turpentine. These are often scattered and inaccessible and their possibilities comparatively little known so that they are not worked commercially at present (*71*, *208*). The species are blue, Tinyu, Khasia, and Himalayan pine. Blue pine (*Pinus excelsa* Wallich) (*489*, *491*) is classed as white pine and yields less freely than chir pine. Tinyu (*P. merkusii* Jungh and de Vriese) (*37*, *38*, *454*, *490*) and Khasia pine (*P. khasya* Royle) (*39*, *491*) are often associated in the forests and have similar gum (*493*), although that from Khasia pine is known to vary with the locality in which the tree grows. The Himalayan edible pine (*P. gerardiana* Wallich) is little used at present except for its seeds, which are a staple food in some regions (*489*).

TURPENTINING METHODS (*92*, *138*)

The French method of turpentining with some modifications is used in India. The methods used in the United States were regarded as too

FIGURE 77.—A, Chipper using a ladder while freshening a face. *B*, Chipper with chipping tool, ladder, and collecting can. *C*, The white paint (applied for photographing but not in actual practice) marks the boundary within which the bark has been scraped and thinned over the area to be occupied by the face. The face shown has been chipped for a half season. *D*, Close view of the face shown in *C*, photographed just after chipping. Note the smooth surface of the face down which the droplets of gum flow into the cup. *E*, Chipping a face on a spiral-grain tree. *F*, Coolie at work chipping while the gum in the cup drains through the strainer into the collecting can. Gum that sticks to the cup is scraped out with the wooden spoon shown projecting from can. *G*, Position taken by tapper when freshening a low first-year face (end of season); when actually chipping the cup is removed.

wasteful for adoption by the British forest officers, many of whom were familiar, as a result of their training, with French practices. In India, as in France, a primary requirement of regular turpentining is the maintenance of the trees in a healthy and flourishing condition.

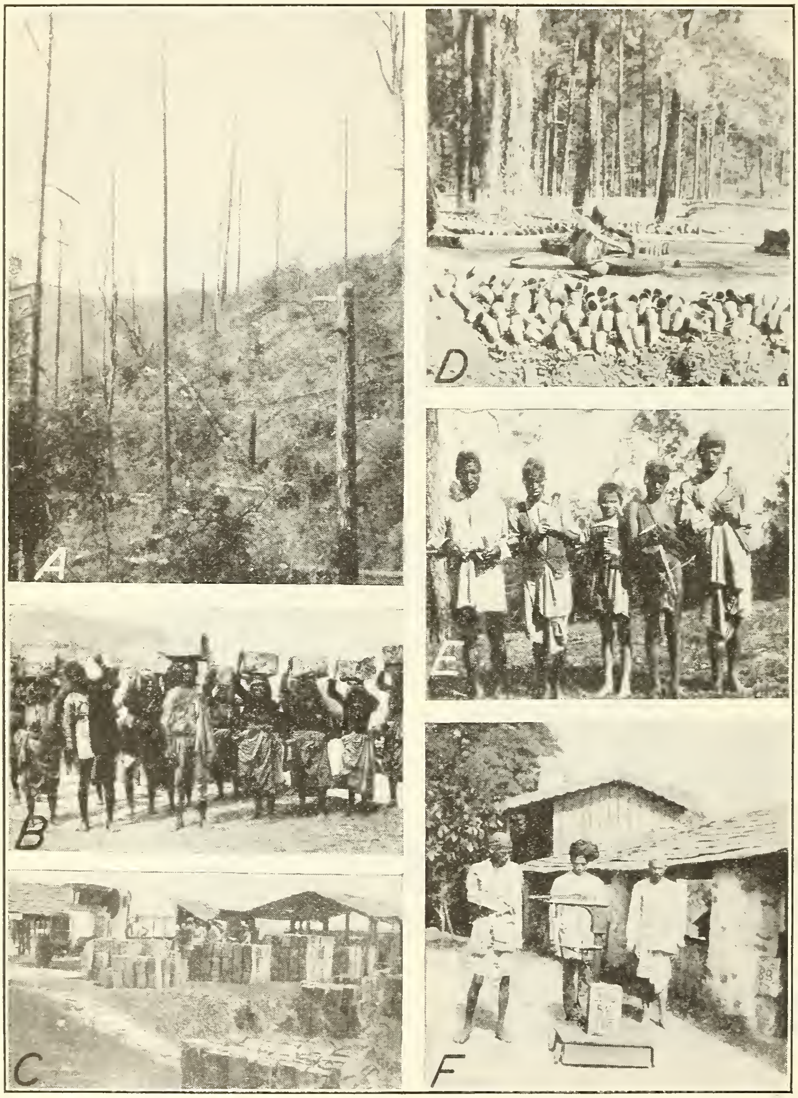

FIGURE 78.—*A*, All the trees shown were killed by an accidental fire occurring in an abnormally dry year; *B*, coolies transporting gum from the forest to a resin depot; *C*, resin depot showing gum being loaded on a truck; *D*, making earthenware cups for gum; *E*, youths are the best class of labor for chipping; *F*, can of gum with top soldered in place ready for acceptance.

WORKING PROCEDURE

The responsibility for working the pine forests of India lies with the forest officers of the British Government. The work in the forest is done by closely supervised native laborers (figs. 77 and 78).

FIRE IN THE WOODS

Strict fire prevention where feasible, or carefully controlled burning, especially in the turpentine woods, have been used by the forest officers in India (*132*).

REMOVAL OF OUTER BARK

All loose bark is removed above and alongside of the place where the face of the year is to be cut (fig. 77, *C*) by rubbing the bark with the side of the chipping tool or chipping it lightly.

SEASON OF CHIPPING

The installation of crops begins by the middle of January and must be completed by February 28 for it is required that chipping begin not later than March 1. The season closes the first week in November.

FREQUENCY OF CHIPPING

Trees are chipped five times a month, that is, once in 6 days. The gum is collected from the cup by the chipper at each chipping (fig. 77, *E* and *F*).

CUPS AND APRONS

Clay cups are used that are 6 inches high and 4 inches broad (outside measurement) at the top. A hole, large enough to permit a nail head to pass through, is placed near the top of the cup (figs. 77 and 79, F). The cups are partly covered with clay lids 5½ inches in diameter. A ridge 3 inches in diameter is placed on the under side of the lid to aid in holding it in place. The apron is cut out of tin and usually lasts 4 or 5 years. The apron is 2 by 6 inches in size (fig. 79, *C*) and is inserted in chisel cuts in the bark at the base of the tree or in cuts one-fourth of an inch deep in the face when cups are raised (fig. 77). Wire nails 1½ or 2 inches long are used for hanging the cups. They are placed about 1 inch below the aprons.

TOOLS AND EQUIPMENT

An adze is used in India for chipping (figs. 77, *A*, *B*, *E*, *F*, *G*, and 79, *D*). It differs from the French tool in that it is straight-edged. The curvature of the blade prevents cutting too deeply into the wood. The width of the cutting edge is between 2 and 2½ inches. The importance of keeping the tools keen and sharp is stressed.

A sharp chisel with a curved cutting edge measuring about 6 inches, driven with a hardwood mallet, is used to make the cuts for inserting the aprons in trees (fig. 79, *B*).

A combined scraper and face measurer 3.75 inches wide, with an outstanding piece 1 inch deep and three-fourths of an inch wide, and made of galvanized iron or tin, is carried by each chipper.

Cans, generally those in which kerosene has been sold, are used for collecting the gum (fig. 77, *B*, *E*, and *F*). The gum is packed for transportation to the distilleries in this same type of can, but with the original top resoldered intact (fig. 78, *B*). Before packing, the gum as it comes from the cup is strained through a wire-gauze strainer having four meshes to the inch (fig. 77, *E* and *F*).

Light ladders are carried to enable the chipper to freshen the surface of the high channels in 5-year work (fig. 77, *A* and *B*).

Nail pullers are used for removing the nails from the trees at the end of each year's work.

FACE

The shape of the face used in India is squarer both at the top and sides than is customary in France. This shape was adopted as an adjustment to the twisted grain that occurs frequently in Indian pines, and which makes the cutting of a smoothly curved edge difficult (fig. 76, *E*, and fig. 77, *C*, *D*, *E*, and *G*). The first wound is made preferably on the south side of the tree, and is about 6 inches in height, 3¾ inches wide, and three-fourths of an inch deep. At each chipping the height is increased about one-half inch, and about 6 inches of the old surface is freshened by a tapering-downward cut. The total annual height of the faces has been reduced from 24 to 14

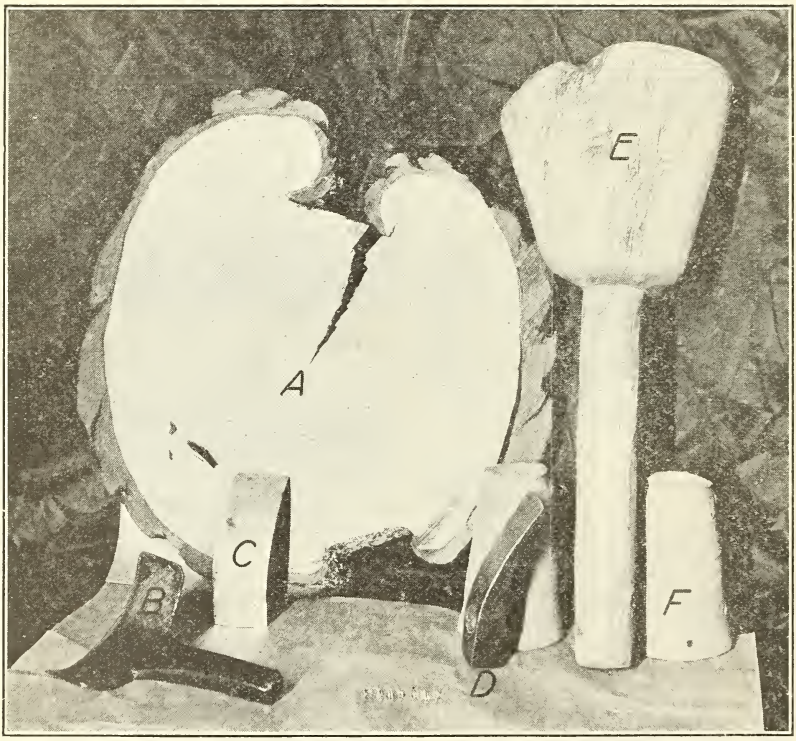

FIGURE 79.—*A*, Disk showing light chipping, face healing over; *B*, tool for inserting apron; *C*, apron; *D*, head for chipping tool; *E*, mallet; *F*, clay cup.

inches during recent years. Faces ¾ to 1 inch deep are permitted in light chipping. In the heavy chipping, used in the period just preceding the time when the trees are to be cut, the chipping may extend into the wood to a depth not greater than 2 inches. The yield is greater from the deep chipping, but not in direct proportion to the depth, and many pitch-soaked and dry faces occur among the heavily chipped trees. The smooth surface of the face facilitates the passage of the gum to the cup.

Bark bars 4½ inches wide are maintained between faces. The apron is inserted in the bark about 6 inches above the ground and about 1½ inches below the face. Cups are raised each year. The aprons are removed each year, cleaned of the adhering gum by burning, and then hammered into shape and used again. When the aprons are raised they are inserted in chisel cuts placed about 4 inches below the end of the last freshening on the face.

Needles, chips, and bark are kept raked away from the base of the trees for a distance of 4 feet as a protection against fire.

Although there is some variation due to crown development and other factors, faces on mature trees have been found to heal over at an average rate of about one-tenth of an inch a year. Immature trees appeared to heal a little more slowly and overmature trees only about half as fast as mature trees. The healing is best at the tops and at the bottoms of the faces.

THE CHIPPER'S TASK

The chipper chips and empties the cups on 1,000 faces throughout the season. It is his duty at each collection to remove the cup cover and invert the cup so that its contents will drain through the strainer into the collecting can (fig. 77, *E* and *F*). He then removes any loose bark in the vicinity of the face, thins the bark to one-fourth of an inch thick for 6 inches above the top of the face and freshens the face with his adze. Next he cleans the apron with the scraper, clears away any debris on the 4-foot area about the base of the tree, and lastly, after removing, with the aid of a small wooden spoon, any gum that has not run out of the inverted cup into the can, he rehangs the cup and replaces the lid.

YIELDS

In India, as elsewhere, notable variation in the yielding power of the trees has been observed. The large trees are generally the best yielders, but among trees of the same size and like condition any individual may yield markedly more or less than could be anticipated. Improvements in operation have been such that yields have increased about 25 percent per unit during the last decade. The gum contains about 20 percent of turpentine, 73 percent of rosin, and 7 percent of water and impurities. Each chipper is responsible for the chipping and the collecting of the gum from 1,000 faces, which means about 700 trees growing on 25 to 30 acres. The average annual yield per face is about 4 to 4½ pounds. The average yield per tree from light working is about 6½ pounds (more than one face on some trees); in heavy working it is about 25 pounds per tree. No scrape is allowed to collect on the faces so that there is no loss of product from this source.

FOREST MANAGEMENT

The Government forests in India are made up of territorial divisions known as blocks, separated by natural features, such as ridges, spurs, and ravines. These are subdivided into compartments (*455*). Forest depots on cart roads are located in each block but may vary widely in the volume of product handled. For example, one depot may receive the product of the work of 10 coolies caring for 1,000

faces each, and another the yields from 50,000 or more such faces. The gum may be transported by coolies, mules, ponies, camels, or bullocks over forest trails and roads. Even goats and sheep have been tried for carriers. Where roads are available, carts, autotrucks, and railroads are used.

Continuous light chipping (no rest periods between workings) is now practiced. One face is placed on trees 10 to 17 inches in diameter; two faces on trees with diameters of 17 to 22 inches; and three on trees of more than 22 inches in diameter. The trees yield uninterruptedly for about 60 years out of a life of 125 years. Rotations of from 80 to 160 years are planned, for large trees are desired because thinning is costly and regeneration on the broken mountain slopes difficult and uneconomical to establish for short workings. Regeneration, however, can be secured, and the seedlings are hardy and even capable of sprout growth after fire. Turpentining is not held to reduce either quality or quantity of seed.

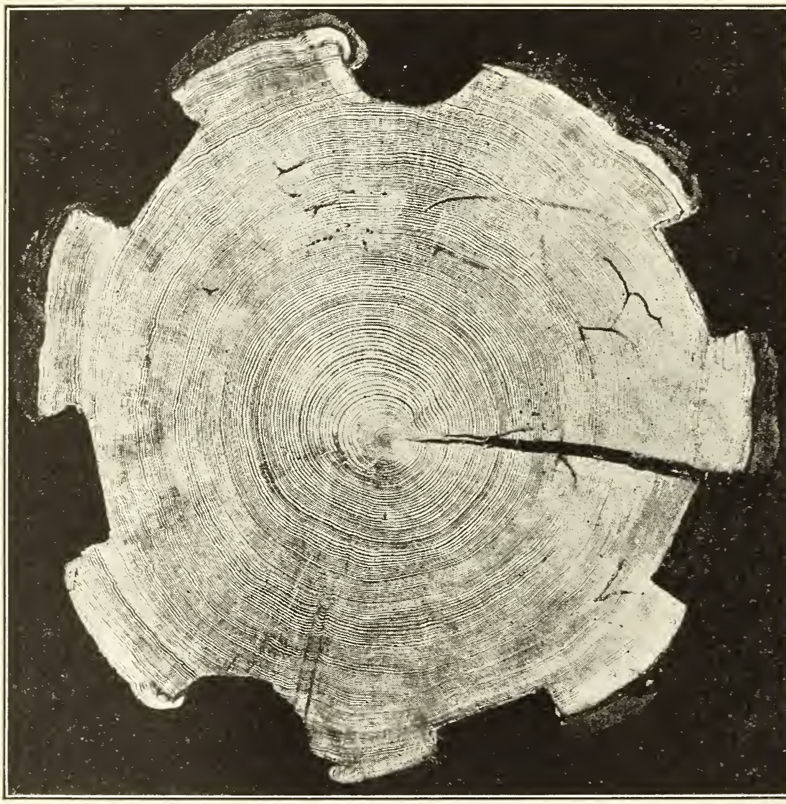

FIGURE 80.—Disk from tree showing the result of heavy chipping with many faces. Two faces with curved outlines were cut on the tree during earlier light working.

When the time approaches for felling a stand, the trees are worked with heavy chipping (fig. 80) using 5 or more faces per tree for a period of usually 5 years. Six to 10 mother trees per acre are

reserved for seeding purposes when a tract is cleared. The slash from the felling is burned, and regeneration follows in a few years.

Chir pine when very young may be destroyed by fire so that about 8 years of strict fire protection are planned for regenerating areas. The trees are considered to be fairly safe under carefully regulated controlled burning when they are about 12 feet tall, at which time the mother trees are cut. The management plans include general fire protection until trees are 25 to 30 years of age. There is always the recognized hazard of the development of impenetrable thickets when vigorous natural regeneration is left for 12 years without burning. The general practice of burning once in 3 years during suitable weather in the winter is common. Fire in summer or at a very dry period is extremely destructive (fig. *78*, *A*).

It is held that turpentining as practiced in India is without serious effect upon the final value of the lumber. The scarred butts, however, are culled. This conclusion is also affected by the fact that excellent hardwoods are abundant and consequently pines are not so highly valued for their wood as in some countries. The production of naval stores made possible as it is by the cheap labor available, is held to give satisfactory profits in normal years. The returns from the gum are often greater than those from the timber.

Although destructive agencies are present in the forests it is to be noted that, for example, grazing is excluded from forest areas in the first stages of regeneration and that snakes, on account of which there is much forest burning in the United States, are not a factor in Indian forest management. Moreover, no serious insect damage in turpentined stands is reported (*300*, *506*). Fungi, however, are known that cause heart rot, such as the red heart rot (*Trametes pini* Fries) of southern pine (*301*); also a needle rust (*Peridermium campanatum* Barclay) and some others.

ADVANTAGES OF THE METHODS USED

The care exercised in the practice of light chipping, using narrow faces to maintain the health and vigor of the trees while securing a sustained yield of gum is an excellent feature of the Indian system of turpentining.

The frequent dipping and the cleaning of the faces and aprons from gum prevents scrape production and tends to reduce losses, such as are now prevalent in the United States. The smooth face appears as a highly desirable feature.

The use of covers on the cups seems to be a practice worthy of trial elsewhere.

The distilling carried on at centralized distilleries where expert handling and control of operations are possible is an example of the advantages resulting from modern tendencies toward better methods and standardized high-grade production. Sun bleaching is practiced in India as in France for producing very pale rosins.

ALL OTHER COUNTRIES[37]

Since over 80 percent of the world's naval stores was produced in 1931 by the United States and France, it is evident that the remaining score of other countries which produce naval stores have a rela-

[37] By Eloise Gerry, Forest Products Laboratory.

tively small output (*213*, *214*, *459*). Among these Spain and Portugal lead with a production of about 7 and 2 percent, respectively (fig. 1). These two countries use the French method of working, often with heavier chipping, and present no marked differences from the procedure outlined in the description of French methods (p. 145). The species used include maritime pine (*Pinus pinaster* Solander) (*372*, *480*, *481*), Aleppo pine (*157*), Corsican pine (*P. Laricio* Poiret) (*177*, *437*), stone pine (*P. pinea* L.) to some extent in Portugal, Scotch pine (*P. Silvestris* L.), insignis pine (*P. insignis* D.), and mountain pine (*P. montana* Mill.) (*20*, *21*, *24*, *25*, *26*, *158*, *181*, *189*, *207*, *255*, *339*, *340*, *403*, *405*, *516*, *564*, *581*).

The production of naval stores in India, which totals about 1 percent, has already been discussed in detail (p. 153) since it represents recent, carefully organized practice with a number of unique features. According to available information, therefore, the remaining about 4 percent of the total production is derived from Russia, Finland, Norway, Sweden, Denmark, Germany, Austria, Yugoslavia, Italy, Greece, Manchuria, China, Japan, Dutch East Indies, Philippine Islands, Australia, New Zealand, Mexico, and Central America.

In a number of these countries production is at present either negligible in amount, primitive in execution, or confined primarily to the products of wood distillation. The general situation in regard to naval stores and the species of pines used in the various countries is as follows.

Australia has plantations of French maritime pine on the west coast which will probably soon be old enough for experimental turpentining. New Zealand also has plantations chiefly of Monterey pine (*P. radiata* D. Don.=*P. insignis* Douglas).

In Europe, Russia is undergoing some perhaps extensive, but little known, changes that promise a considerable increase in the turpentining of living trees. They bid fair to change Russia's previous status as a large importer of gum products and a manufacturer primarily of wood-distillation products (*14*, *22*, *23*, *209*, *441*). The enormous forest areas in European and Asiatic Russia make the production of a large volume of gum within the range of possibility in spite of the limitations set by climatic conditions and the fact that the species available, chiefly Scotch pine, is not a high yielder. Mountain pine, black or Corsican pine (*437*), maritime pine, and stone pine (*P. pinea* L.) also occur. Conditions in Poland and Finland (*162*, *358*, *502*) are similar to those in parts of Russia. Turpentining methods in Russia are now receiving the attention of scientific investigators. Methods from France, Germany, and the United States are being applied in place of the excessive, primitive type of wounding formerly practiced where with a circular draw shave the entire surface of the butt of the tree, except for one narrow bar of bark, was exposed to air.

Norway, Sweden, and Denmark produce some wood distillation products, notably Stockholm tar, from Scotch pine.

Germany (*34*), Austria (*560*), and Yugoslavia have produced little gum from living pines since the World War. Although it is possible to obtain these products in Austria, (*177*, *333*, *449*, *450*, *451*, *553*). chiefly from Scotch pine and also from Corsican or Austrian pine, it has not been considered practical when supplies were readily available from other sources (*224*, *320*, *321*, *439*).

Italy has only a small naval stores industry. The species used are Scotch, maritime (*140*), and Corsican pines (*366*, *433*, *467*).

In Greece the production of pitch and resins is known to date back to the very earliest times. The species used is Aleppo pine. About 90 percent of the rosin and turpentine produced is exported. Gum is added to the grape juice when wine is made and later partly recovered when the residues from the wine dregs are distilled (*1*, *19*, *156*, *359*, *407*).

China, Indo-China, and Japan do not produce significant quantities of naval stores, but plantations of pine have been made in both China and Japan and Chinese white pine (*Pinus koraiensis* S. et Z.), Masson pine (*P. massoniana* Lambe), and Thunberg pine (*P. thunbergii* Parl) have been used (*17*, *210*). In Manchuria wood-distillation products are prepared.

In the Philippine Islands the pine gums have been exploited to only a small extent. Two species of pine occur, however, which yield turpentine. These are Benguet pine (*Pinus insularis* Endl.) and Mindoro pine (*Pinus merkusii* Jungh). Turpentining of Benguet pine begun in 1930 was continued throughout 1931. Preliminary reports show that there is a bright prospect in turpentining Benguet pines, for while these trees produce less gum in a given time than longleaf pine of the United States, yet the fact that in Baguio it is possible to operate throughout the year, causes the actual amount obtainable in a year per tree to be greater than in the United States. Among the other problems being investigated are the yield of resin in relation to the thickness of the bark, and the composition of resin to the various types of barks (*196*, *388*, *552*).

In the Dutch East Indies an active exploitation of *Pinus merkusii* Jungh, which is reported to give very high yields, is in progress. Benguet pine from the Philippines has also been planted and successfully turpentined (*8*, *88*, *200*, *212*, *242*, *258*, *326*, *442*, *443*, *514*, *531*).

In North America (exclusive of the United States) naval stores are produced in Mexico (fig. 1). The exploitation of several of the numerous pines in Mexico is possible. Among the species used are ponderosa pine, Arizona pine (*P. arizonica* Engelmann), jalocote or ocote pine (*P. teocote macrocarpa* Shaw) and Chihuahua pine (*P. chihuahuana* Engelmann or *P. leiophylla* Schlectendal and Chamisso). The stands, mainly of virgin growth, occur in mountainous country, at elevations of 4,000 to 9,000 feet above sea level, in some 10 States. The Republic of Mexico has recently enacted laws designed to conserve and perpetuate the utilization since much crude and wasteful exploitation has occured. Until very recently boxing was a common practice in several districts. The new laws require that no tree less than 12 inches in diameter be cupped, that 5-inch bark bars be preserved, and that not more than two cups be hung on any tree. A considerable part of the turpentine produced is exported, much of it coming to the markets of the Western States. The rosin is largely consumed in Mexico in the soap and other industries (*28*, *52*, *180*, *218*, *240*, *319*, *341*, *452*, *479*, *505*, *507*, *508*, *517*).

In Central America, notably in Honduras (*9*, *179*, *309*, *310*, *446*), and in the West Indies, particularly in Santo Domingo, turpentining has been tried, concessions held, and there are still oppor-

tunities for further exploitation (*65*). The species is known as Caribbean pitch pine (*Pinus caribaea* Morelet) but botanically is held to be identical with the slash pine of the United States.

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